CITY OF MANCHESTER
NATURAL RESOURCES INVENTORY

Prepared for:
Manchester Conservation Commission

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Cover Photograph A view downstream along the Piscataquog River at the Piscataquog River Park. This park hosts numerous trails and a popular fishing area.

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INTRODUCTION

Population Growth and Development

New Hampshire's population growth was twofold that of the other New England states in the 1990s and early 2000s (NH Office of Energy and Planning 1998). There was a rise in population of 17.2% between 1990 and 2004 alone. However, recent trends have suggested that the rate of population growth in the Granite State seems to have slowed down overall.

According to Johnson (2019), New Hampshire experienced only 3% population growth from 2000 to 2018. This growth is fairly modest compared to the last four decades. This is mainly due to lower birth rates and lower net migration (people moving into the state versus moving out of the state). In fact, New Hampshire's recent population growth is mostly attributed to people moving to the Granite State from other states and countries. This seems appropriate since New Hampshire is an absolutely wonderful place to live and work for so many reasons.

In addition, it was estimated that New Hampshire would experience about a 9% increase in population growth from 2010-2040 (RLS Demographics, LLC 2016). However, this prediction may shift upwards in light of climate change and the current pandemic, among other factors, as people seek the less populated, rural and suburban settings our state has to offer. New Hampshire's development pressure, particularly in the southern half of the state, will tax the state's natural resources if not managed with diligence.

The City of Manchester's population in 2009 was 109,061 and 111,657 in 2018 (Open Data Network 2020). This City, also known as the Queen City, has experienced and average annual population growth of 0.26%. Furthermore, it has been projected to increase to 113,099 by 2023. While this projected growth might seem modest it can continue to impact Manchester's natural resources and limited open spaces if development is not managed in a proactive manner for conservative measures.

The bulk of population growth is in the southern half of the state; however, 75% of conservation lands are located in the northern regions. This entrusts towns in the southern half of New Hampshire with the responsibility of managing their natural

resources and biological diversity, and establishes citizens as stewards of the land, requiring the use of informed decision making to promote a more sustainable approach to land use planning.

Manchester faces challenges that are familiar to many communities in southern New Hampshire. The rate of residential and commercial development and growth in general has continued to increase, especially over the past three decades. Larger challenges not widely foreseen half a century ago are now in plain sight, as global climate change and invasive species have become new causes for concern. With the understanding that growth and change will occur, the City is faced with choices about directing growth and preservation so that a suitable balance can be achieved. Planning for the protection of natural resources and open space is a critical and positive step towards solutions to these challenges.

Natural Resource Inventory

One of the best first steps in planning for growth and development is to conduct a Natural Resources Inventory (NRI). An NRI is a list and description of the natural elements that are tied to geography within and adjacent to a town (or even a watershed or larger region). These can include such elements as wetlands, aquifers, ponds, rivers, forests, plants, soils, and wildlife. These data can be created from existing sources or from field-based assessments to better reflect the extent of natural resources within a community.

Time, money, and human resources are limited in the accomplishment of conservation and land stewardship. An NRI is a critical asset that will help Manchester to understand the location and quality of its natural resources and provides a solid objective basis for all conservation planning activities. An NRI is not only an important starting point for informing conservation decisions, it is also a core responsibility written into the enabling State legislation allowing for the existence and authority of conservation commissions. In conjunction with the conservation planning that it can inform, it can also provide a basis for public outreach, which can result in further support for land conservation, as well as land stewardship and mitigation.

New Hampshire statutes mandate that communities with a conservation commission shall create an NRI. This is generally the responsibility of the local Conservation Commission, whose purpose is "for the proper utilization and protection of natural resources and for the protection of watershed resources" of the town or city. In particular, RSA 36-A:2 continues to state, "Such commission shall conduct researches into its local land and water areas [and] … shall keep an index of all open space and natural, aesthetic, or ecological areas within the city or town … with the plan of obtaining information pertinent to the proper utilization of such areas, including lands owned by the state or lands owned by a town or city. It shall keep an index of all marshlands, swamps and all other wetlands in a like manner…"

An NRI can serve as the basis for developing innovative land use planning that can be adopted to help protect various resources, such as wetlands, wildlife habitats, and biological diversity. Biological diversity, or biodiversity, refers to the variety, variability, and complexity of life in all its forms and includes various ecological processes (for example, nutrient cycling, flooding, fires, wind events, and succession) that have helped to shape species over time.

Biodiversity includes various levels of ecological organization such as individual species and their genes that have evolved over time, as well as the many intricate plant and wildlife populations. It refers to even higher levels of organization including the assemblage of ecological communities[1] and even entire ecosystems, such as wetlands, woodlands, and rivers. Therefore, the concept of biodiversity engenders all levels of biological organization and the interactions of living organisms within their physical environments. At its heart, the understanding of the dynamics of biodiversity can lead to the development of protection strategies, helping to ensure a healthy environment for humans, as well as all other life forms.

This form of land use planning should not be a static directory but one that stays current with changes. It is a vision that should be based on the principles of conservation biology and that incorporates the current ecological structure of a given area (such as a

[1] An ecological community is a group of two or more populations of different species found in the same place. For example, this would include the wetland bird community of the Great Cohas Swamp wetland complex.

town, a watershed, or an entire region). Thus, conservation planning ideally strives to incorporate the socio-economic fabric of our world with that of the ecological structure. This effort can help build more sustainable and resilient New Hampshire communities far into the future as a result of implementing comprehensive land use planning that considers both our natural environment and built infrastructure.

Planning for the conservation of natural resources and biodiversity is not a new concept. It has helped in such efforts as the recovery of the American bald eagle; has assisted in building preserves and managing other lands for species of conservation concern, as well as our most common species; aided in the identification of biodiversity hot spots; and has helped to identify and protect critical wildlife habitats within our landscape. It has been a center piece for natural resources protection, restoration, and adaptive management for the past four decades.

The need for this type of informed land use planning is becoming more evident with the passing of time, however. Ecosystems and their constituents have long been susceptible to long-term degradation from overexploitation and misuse of natural resources. This has led to the recent loss of critical habitats as a result of sprawling residential and commercial developments. While the past few decades certainly have seen significant development and land conversion, there has been a concomitant rise in conservation planning efforts over the same time period, especially in New Hampshire.

Manchester recently published a draft of their latest Master Plan in 2020, providing a guide for the overall character and development of the Queen City. The Natural Resources chapter acknowledges the need for protection of its natural habitats. It continues to state that “In addition to increasing the value of adjacent properties, a network of green spaces connected by green corridors, greenways, and green streets will help protect and enhance the natural resources of the City including creeks, floodplains, existing trees, habitat areas, and wildlife corridors. Together, they form a ‘big picture green print’ that helps elected officials and partner agencies prioritize land acquisition and infrastructure projects” (Manchester Master Plan draft 2020).

In developing this chapter, the City identified the following basic objectives to meet its vision to support the stewardship of its natural resources.

- Partner with state, regional, or other nonprofit groups working in the area to mitigate the impacts of new development on existing natural systems. At a minimum, include new rules and standards in the City's code that incorporates open space as a meaningful component of new development, including parks, tree preservation, stormwater retention, recreation, animal habitat protection, or preserving scenic views.
- Protect key environmental features, especially the unique natural features in the eastern and western parts of the City, while accommodating development. Reimagine our relationship to natural systems, restore water quality and riparian areas. Increase connections between citizens and open space and provide amenities in new developments.
- Integrate open space and stormwater infrastructure as amenities in new development and existing neighborhoods.
- Program City resources to prepare an updated facilities plan for parks. The new facilities plan should focus on building a comprehensive and continuous green infrastructure network that connects key destinations via green corridors, including greenways for increasing regional and local walking and biking trips.

Statement of Purpose

The Manchester Natural Resources Inventory (NRI) was initiated in February 2020. The overall scope of this project was to develop an enhanced NRI – primarily map based but with various field observations – to support the City's natural resource protection efforts and provide a basis for informed land use and conservation planning. Goals of the project were 1) to review and analyze natural resources data and reports currently known, 2) to develop a series of NRI maps designed for educational and planning purposes, 3) to refine existing data such as grasslands, active agricultural lands, conservation lands, and potential vernal pools, 4) to conduct field investigations for various wildlife habitats and significant natural communities as well as biodiversity, including species of conservation concern, and 5) to combine the various natural

resources data and maps into this NRI report and conduct a public presentation of our findings.

The information found herein can be used in many ways by elected and appointed officials, landowners, natural resource professionals, and the public. The NRI is intended to provide more detailed information to support the following Conservation Commission goals:

- Balance the development of the City with preservation of the natural resources for wildlife and recreation use,
- Identify City-owned land that may warrant protection by easements or other means,
- Identify additional land that may warrant protection,
- Identify current or potential threats to these resources in order to make land-use decisions on a parcel basis or inform changes to current land-use regulations,
- Identify challenges and projects that should be a focus to the Commission,
- Identify locations of invasive species (plant and animal) that warrant the Commission's attention,
- Identify endangered and threatened species and their approximate location, and
- Identify and rank potential mitigation projects that could be used to offset future development or maintenance projects.

Land Use and Open Space - Aerial Photography View

The following aerial photography map provides a perspective of the current areas of development and open space in Manchester (Figure 1). This map displays roads, streams, rivers, ponds, lakes, and wetlands as base layers to assist the viewer in navigating throughout the City with a bird's eye view. Also included are the various public and private conservation lands.

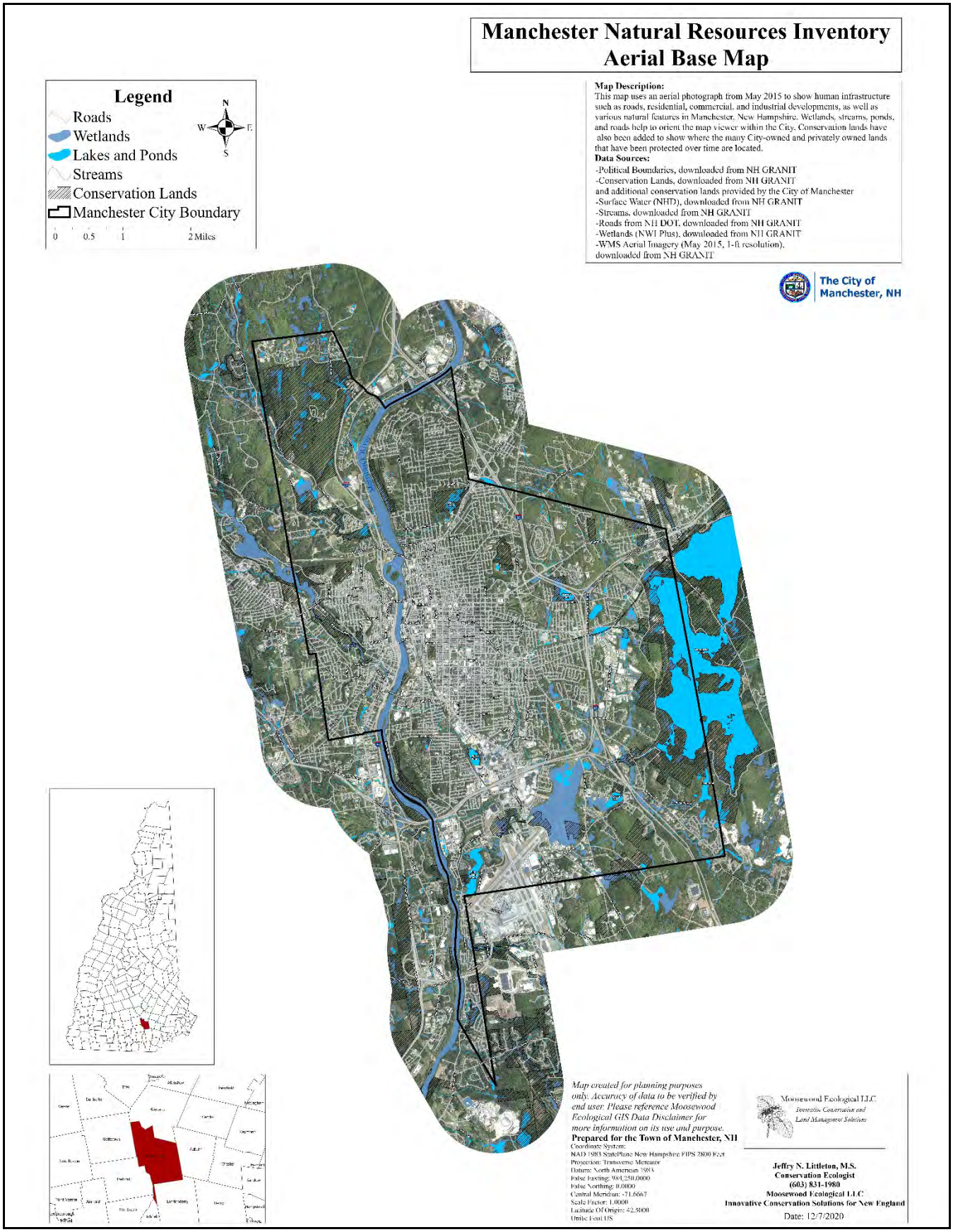

Figure 1 Aerial photography base map.

WATER RESOURCES

Water resources represent some of our most fragile ecosystems and are particularly sensitive to certain types of land use. Water resources include both surface waters, such as streams, ponds, and wetlands, and groundwater resources, such as aquifers. These resources provide a variety of critical ecological functions and societal values, including: water quality maintenance, flood control, wildlife and fisheries habitats, drinking water sources, recreation, visual quality and aesthetics, rare and endangered species habitat and natural communities, groundwater recharge and discharge, shoreline stabilization, educational and scientific value, and overall biological diversity.

Wetlands

Wetlands generally include familiar places such as marshes, wet meadows, beaver impoundments, swamps, fens, bogs, and other surface water bodies. As noted above, they perform a variety of ecological functions and values, such as providing significant habitats for wildlife and plants, maintaining good water quality, storing floodwaters, and recreation opportunities.

In New Hampshire, wetlands are defined by RSA 482-A:2 as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal conditions does support, a prevalence of vegetation typically adapted for life in saturated soils conditions." Areas regulated by the NH Dept. of Environmental Services Wetlands Bureau RSA 482-A:2 include forested, scrub-shrub, and emergent wetlands, marshes, wet meadows, bogs, shorelines of streams, rivers, lakes, and ponds, and prime wetland buffers.

The US Fish and Wildlife Service mapped wetlands throughout the United States through its National Wetlands Inventory (NWI) program. This hierarchal system of classification was designed as a systematic method for describing types of wetlands within a defined geographic location (i.e., town or watershed) and to determine wetlands loss over time.

This nationwide mapping effort is used by the State, municipalities, and natural resource managers to promote the understanding, conservation, and restoration of wetlands. The NWI provides some useful information, including the type of wetland as well as its hydrology, associated plant communities, water chemistry, and other modifiers such as man-made dams and beaver influence. The NH Department of Environmental Services recently updated the NWI for certain parts of the state, including Manchester. This new data set is referred to as the NWI Plus wetlands.

Manchester has roughly 2,183 acres of wetlands dispersed throughout the City (Table 1 & Figure 5). These include three main wetland systems - lacustrine, riverine, and palustrine. Lacustrine wetlands include lakes and ponds greater than 8.2 feet in depth. Examples of lacustrine wetlands in Manchester include Massabesic Lake along the eastern City boundary, as well as Pine Island Pond and Crystal Lake in the southern part of Manchester. Riverine wetlands are those associated with rivers, which includes Merrimack River and Piscataquog River.

All other wetlands in Manchester are palustrine wetlands, defined as shallow, freshwater sites dominated by vegetation. These include familiar places such as aquatic beds dominated with lily pads and other floating plants, emergent marshes, shrub and forested swamps, and beaver ponds (unconsolidated bottom wetlands). The largest and most extensive wetlands can be found along the various streams and rivers; however, Manchester's landscape supports many small, isolated wetlands as well.

Table 1 Summary of wetlands in Manchester.

Wetland Classification	Area (acres)
Lacustrine	683.7
Riverine	541.4
Palustrine	
Unconsolidated Bottom	79.6
Aquatic Bed	71.1
Emergent Marsh	333.6
Scrub-shrub Swamp	18.2
Forested Swamp	455.2

SOURCE: National Wetlands Inventory Plus (2017).

Figure 2 Wetlands supply a multitude of ecological and societal values, providing important wildlife habitat, recreation, flood control, water quality management, and education.

In 2015, West Environmental, Inc. conducted a study for the Manchester Conservation Commission to evaluate over 50 wetlands in the City based on previous studies from 2002-2007 (West 2015). As a result of the wetlands evaluation, Manchester designated 17 highest ranked wetlands, covering 591 acres and ranging in size from ½ acre to 360 acres (Figure 5). These include the large wetland complex associated with Cohas Brook, five wetlands adjacent to and near Massabesic Lake, and 11 wetlands located on the Manchester Cedar Swamp Preserve. All but three of these wetlands are located on conservation lands.

To adequately characterize and delineate wetlands, it is important to consider hydric soils, which are wetland soils categorized as poorly drained and very poorly

drained. These soil types have been mapped by the USDA Natural Resources Conservation Service for the entire state. Poorly drained soils in Manchester are estimated to cover about 834 acres while very poorly drained soils cover 1,321 acres, based on GIS calculations.

Watersheds

All the portions of the earth are a part of a watershed. Watersheds exist at an almost infinite range of scales, from the tiniest tributary stream that does not show on any map to major continent-draining rivers. Regardless of their scale, watersheds are a convenient way to parse the landscape into smaller ecological units. All water resources within a watershed drain toward a common water resource, which may be a lake, pond, or wetland; the land use within a watershed can affect the quality and quantity of surface waters and the underlying aquifers. Land use planning based on watershed protection can help protect a municipality's water resources, ensuring clean water for humans and ecosystem health. Manchester is divided into three major local watersheds, including Piscataquog River, Cohas Brook, and Little Cohas watersheds (Figure 5). The entire City is situated in the Merrimack River Basin.

Surface Water Bodies

Manchester contains a variety of surface water bodies, including rivers, streams, lakes, and ponds, that are distributed throughout the City (Figure 5). Not only do water bodies provide a multitude of human benefits such as fishing, hunting, boating, swimming, and nature watching, but they are also essential for the diverse wildlife and plants that depend upon these resources for part or all of their life cycle needs. Threats to water resources include potential water quality degradation by mobile, stationary, or area pollution sources; habitat loss due to surrounding land use including unsustainable forestry and agricultural practices; and land conversion associated with roads and various types of developments.

Manchester has a variety of lakes and ponds distributed throughout the City. The US Geological Survey and the NH Dept. of Environmental Services (NHDES) have

identified seven distinct lakes and ponds. These lakes and major ponds cover approximately 724 acres, ranging in size from about 15 acres to 571 acres (Table 2 and Figure 5). All of these waterbodies are included on the NHDES Consolidated List of Water Bodies subject to the Shoreland Water Quality Protection Act under RSA 483-B. Two additional ponded areas are regulated under this Act as well, which are the waterbodies associated with the Amoskeag Dam (478 acres) along the Merrimack River and Kelley Falls Dam (129 acres) along the Piscataquog River. Many other smaller ponds also exist in Manchester but were not distinguished as part of this project.

Figure 3 Massabesic Lake is Manchester's largest water body, serving as a major source of its water supply for the City and other communities.

Table 2 Summary of ponds in Manchester.

Lakes and Ponds	Size (acres)
Massabesic Lake	570.6*
Pine Island Pond	54.0
Dorrs Pond	23.3
Long Pond	22.6
Crystal Lake	21.3
Nutt Pond	17.6
Stevens Pond	15.0

*Area located in Manchester
SOURCE: USGS topography (2004) and NH DES (2020).

Approximately 68 miles of rivers and brooks have been mapped in Manchester (Table 3 and Figure 5). Eight of these have been identified by the U.S. Geological Survey by name. Of the many rivers and streams, four are listed on the NH DES Consolidated List of Water Bodies subject to the Shoreland Water Quality Protection Act under RSA 483-B. These are the Merrimack River, Piscataquog River, Black Brook, and Cohas Brook.

In addition, the Piscataquog River is a Designated River Corridor identified by the NH Department of Environmental Services Rivers Management and Protection Program. Designated Rivers are managed and protected for their outstanding natural and cultural resources. These are governed by the Rivers Management and Protection Act, RSA 483. For more information on the natural and cultural resources of the Piscataquog River and its management plan see the following link.
https://www.des.nh.gov/organization/divisions/water/wmb/rivers/desigriv.htm

Table 3 Summary of rivers and streams in Manchester.

Streams	Length (miles)	Stream Order
Merrimack River	11.3	7th
Piscataquog River	2.4	5th
Cohas Brook	9.0	4th
Black Brook	3.6	4th
Watts Brook	0.2	3rd
Humphrey Brook	4.2	2nd
Milestone Brook	2.4	2nd
Baker Brook	1.7	2nd
Un-named Streams	33.3	1st - 3rd

SOURCE: USGS topography (2004) and hydrogrpahy (2006) datasets.

The Shoreland Water Quality Protection Act (RSA 483-B) is a state statute that was protects the water quality of designated public waters. The Act establishes minimum standards for various setbacks from the reference line based on land use within the designated 250-foot buffer. For most new construction, as well as land excavating and filling, a state permit may be required (certain exemptions apply). As such, all great ponds (>10 acres), fourth order streams[2] or higher, and State-designated rivers have been identified by the NH Dept. of Environmental Services as water bodies that are subject to the Act.

For more details on the Shoreland Water Quality Protection Act, as well as certified administrative rules, refer to the NHDES at http://des.nh.gov/organization/divisions/water/wetlands/cspa/index.htm

[2] Stream ordering is a hierarchy used to define the size of a stream. The smaller the stream order, the smaller the stream. First order streams include the headwater streams that can be found along the steeper slopes in Manchester. When two first order streams converge, they form a second order stream, and so on.

Figure 4 The Piscataquog River provides a major cultural and scenic aspect to Manchester, as well as its versatile wildlife habitat for fish, turtles, otters, and eagles.

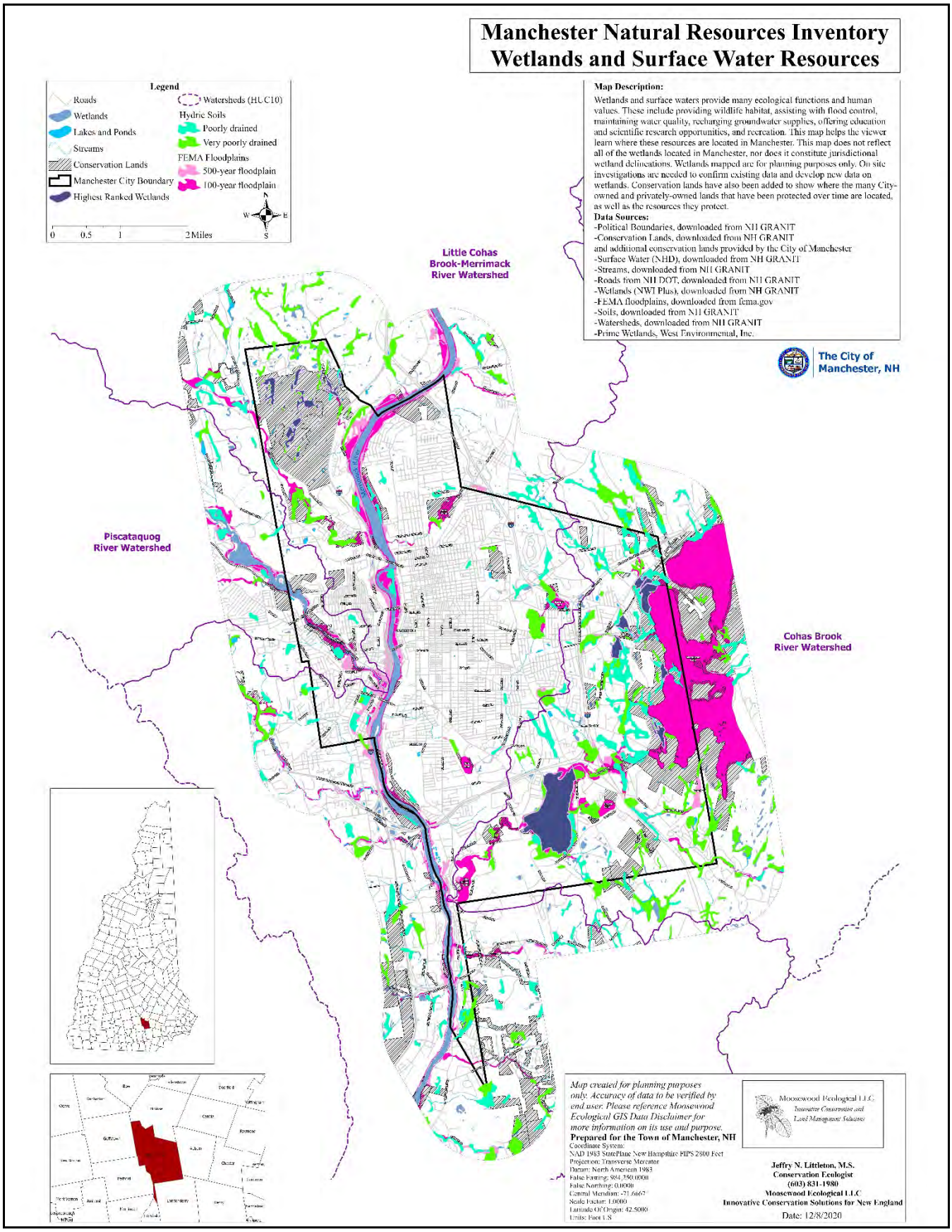

Figure 5 Wetlands and surface waters of Manchester.

Groundwater Resources - Stratified Drift Aquifers

Groundwater resources are stored in two main types of aquifers and can serve as sources for drinking water. Aquifers can be located within saturated areas of sand and gravel deposits or in fractured bedrock. In the last post-glacial period as glaciers melted, these meltwaters left behind layers of sorted sediments including sand and gravel. The spaces between the particles in these sediments provides opportunity for groundwater storage and flow. Groundwater stored in *stratified drift aquifers* of this kind can serve as an excellent source of drinking water. These aquifers shave been mapped by the US Geological Survey (USGS). Locating these geologic features and protecting them as current and future water sources can help to ensure a supply of clean drinking water free of contamination.

Manchester contains approximately 15,440 acres of stratified drift aquifers (Figure 6). As one can see from this groundwater resources map, most of Manchester is underlain by aquifers. These are found in association with the City's largest rivers and brooks, including Merrimack River, Piscataquog River, Black Brook, and Cohas Brook, as well as Massabesic Lake.

Aquifers are typically divided into categories by the USGS based on *transmissivity*, or the rate at which water moves through an aquifer and is measured in square feet per day (ft^2/day). Therefore, higher rates of transmissivity correspond to a potentially higher yield of groundwater. However, the USGS classified Manchester's aquifers as *undifferentiated.*

Undifferentiated means that the USGS did not attempt to characterize the sand and gravel deposits in Manchester. Rick Chormann (2020), State Geologist and Director of the NH Geological Survey, presumes that the USGS did not characterize the transmissivity rates due to the "highly urban nature of most of the area and also because Manchester Water Works was completely reliant on Massabesic Lake for its water supply with an ongoing proposal to augment that with a large withdrawal from the Merrimack River. Significant use of groundwater did not seem to be in their future when the stratified-aquifer project was being completed." Chormann (2020) further explains that "the surficial geology data is available as a geodatabase, but professional hydrogeologic

judgement would be required to estimate transmissivity values from the different surficial geologic map units."

In an attempt to identify potential future public water supplies for communities, the NHDES and the Society for the Protection of NH Forests prepared a Potential Favorable Gravel Well Analysis (PFGWA) for the entire state. This project analyzed stratified drift aquifers, affording the opportunity for town planners and water suppliers to determine quantity and quality constraints on aquifers.

In doing so, the PFGWA creates buffers to avoid all known and potential contamination sources and examines potential well yield to identify the most suitable areas for potential community wells. In effect, this effort is encouraging communities to take proactive measures at protecting their most significant groundwater resources. As such, there are very few sites (just over 2 acres in total) that have been identified by the PFGWA for the City of Manchester. Again, this was an effect of not knowing the transmissivity rates of the aquifers in the Queen City.

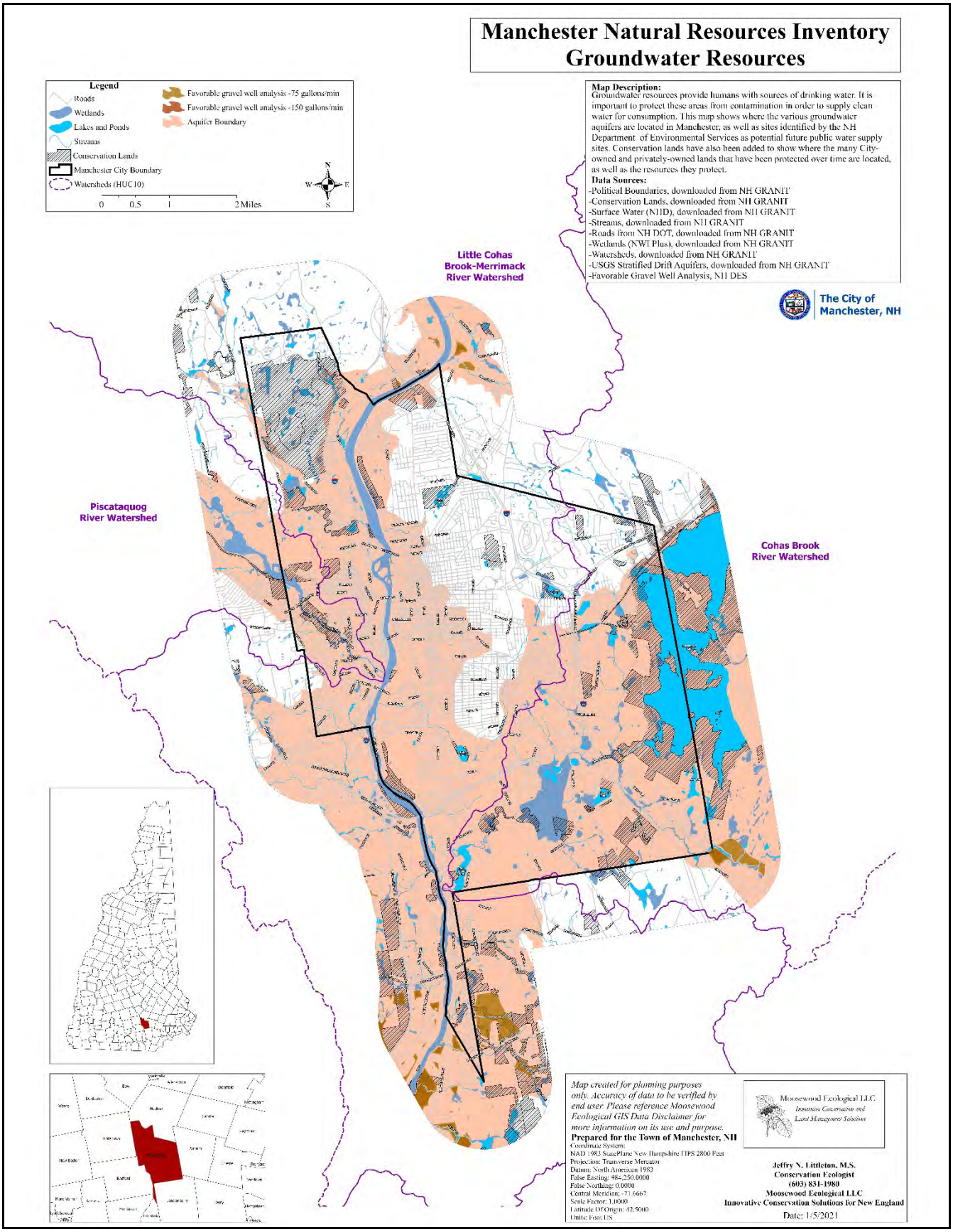

Figure 6 Groundwater resources in Manchester.

ECOLOGICAL RESOURCES

Ecological resources in Manchester include many features such as wildlife habitats, natural communities, and rare species. These natural resources encompass the realm of biodiversity, or the variety and variability of life, which supports healthy ecosystems for wildlife, plants, and humans. However, non-native, invasive species have been colonizing the region for centuries, which has affected our native biodiversity in profound ways.

This largely map-based Natural Resources Inventory was enhanced by field surveys on select properties to assess some of Manchester's biodiversity on the ground. These visits focused on City-owned properties and roadside surveys combined with assessments on private properties where landowners provided permission. These assessments, which are further presented below, provided a representative sample of Manchester's natural landscape to support proactive land use planning, community education, and land stewardship. The following sections provide a glimpse into the range of diverse species and habitats present.

NH Wildlife Action Plan

Manchester's natural landscape supports a variety of wildlife habitats and natural communities, including rivers, streams, ponds, lakes, wetlands, and floodplains interspersed with a variety of upland forests, rocky ridges, and grasslands distributed throughout the City. This diverse landscape supports a high degree of biodiversity.

The NH Fish and Game Department, in cooperation with other agencies, organizations, and individuals, produced the NH Wildlife Action Plan (WAP) in 2005 and last revised it in 2020. This document was designed as a planning and educational tool for federal, state, and municipal governing bodies, conservation commissions, land trusts and other conservation organizations, natural resource professionals, and private landowners, as well as the general public, to promote the conservation and management of NH's biological diversity. The WAP provides a resource for developing informed land use decisions and land management planning. The intent was to ensure that an adequate representation of various wildlife habitats is maintained across New Hampshire's landscape, keeping common species common in New Hampshire and working to prevent the loss of our rare and endangered species.

The WAP project grouped habitats at three scales: broad-scale (matrix forests and sub-watershed groupings), patch-scale (priority habitats such as grasslands and peatlands) and site-scale (documented occurrences of rare and uncommon species and natural communities). Mapped data are available for viewing and use only at the broad- and patch- scale levels. Habitat mapping is intended to predict, not necessarily guarantees that the habitats shown are present. For this reason, field and remote sensing verification is recommended by NH Fish and Game to increase the accuracy of the mapping at the parcel and municipal scale.

A total of twelve wildlife habitats described in the WAP were mapped for Manchester (Table 4 and Figure 8). Potential vernal pools were mapped using 2015 aerial photography interpretation and data collected in the field by Moosewood Ecological LLC during the 2020 field season (Figure 7). Although the WAP recognizes vernal pools as important wildlife habitat, these isolated wetlands have not been mapped for New Hampshire. Vernal pool locations can be predicted through aerial photograph interpretation, providing the first step in learning about their distribution. However, they are best mapped using on-site field assessments and verification.

Table 4 Summary of habitats mapped by the Wildlife Action Plan in Manchester.

Wildlife Habitat	Size/Count	% of City
Appalachian oak-pine	2,410.7 acres	10.8%
Hemlock-hardwood-pine	1,466.1 acres	6.6%
Rocky ridge	2.2 acres	0.01%
Grassland	355.9 acres	1.6%
Floodplain Forest	272.4 acres	1.2%
Marsh and shrub wetland	521.3 acres	2.3%
Peatland	125.6 acres	0.6%
Temperate forested swamp	302.4 acres	1.4%
Vernal Pools	116 pools	N/A
Open water/ponds	1,225.5 acres	5.5%
Streams	68.1 miles	N/A
Sand/Gravel	81.4 acres	0.4%
Barren or Developed	15,672.6 acres	70.1%

SOURCE: NH Wildlife Action Plan (2020), USGS NH Hydrography (2006), Vernal pools developed by Moosewood Ecological LLC from field assessments and aerial photography interpretation (2020), Grasslands refined by Moosewood Ecological LLC from aerial photography interpretation (2020).

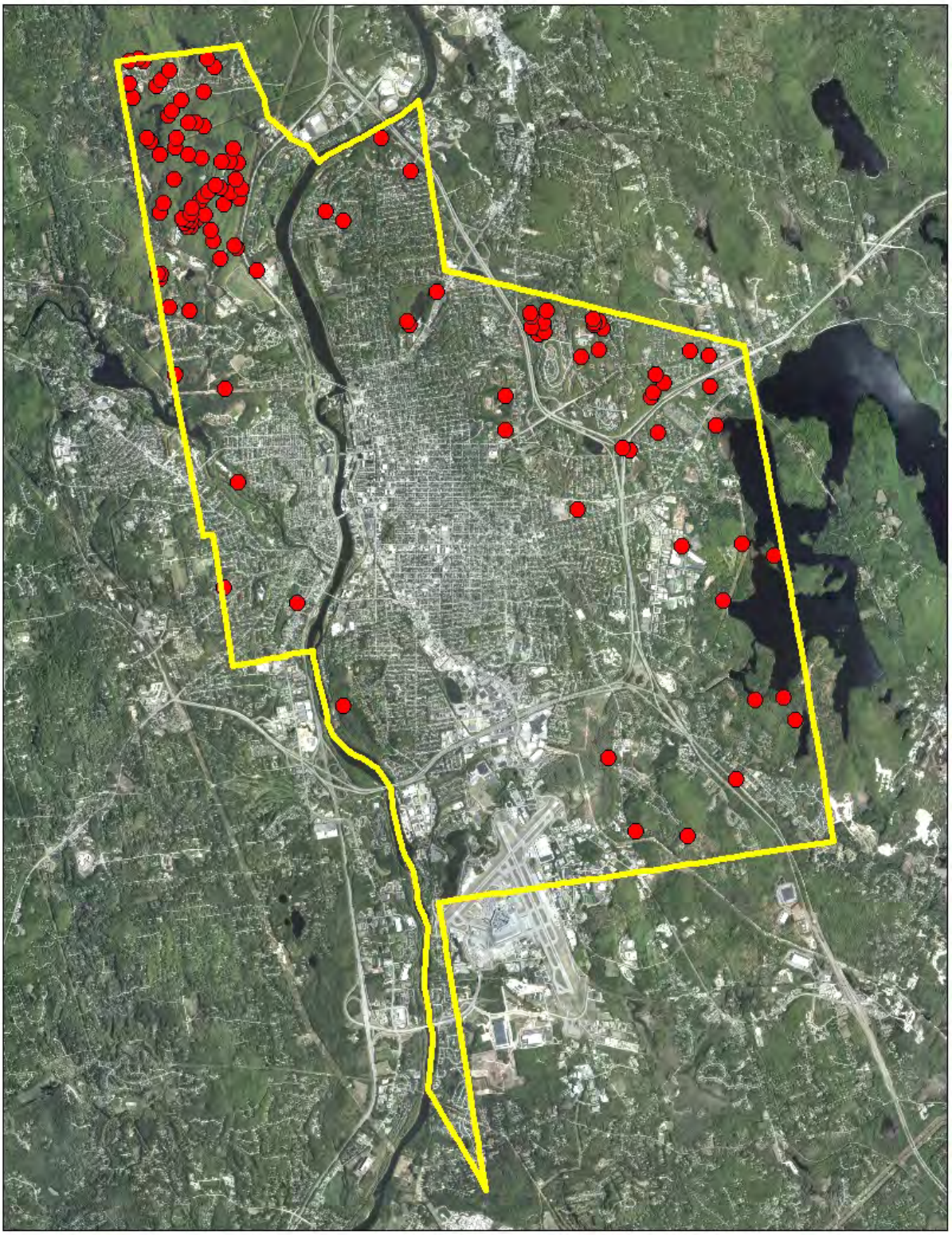

Figure 7 Potential vernal pools in Manchester.

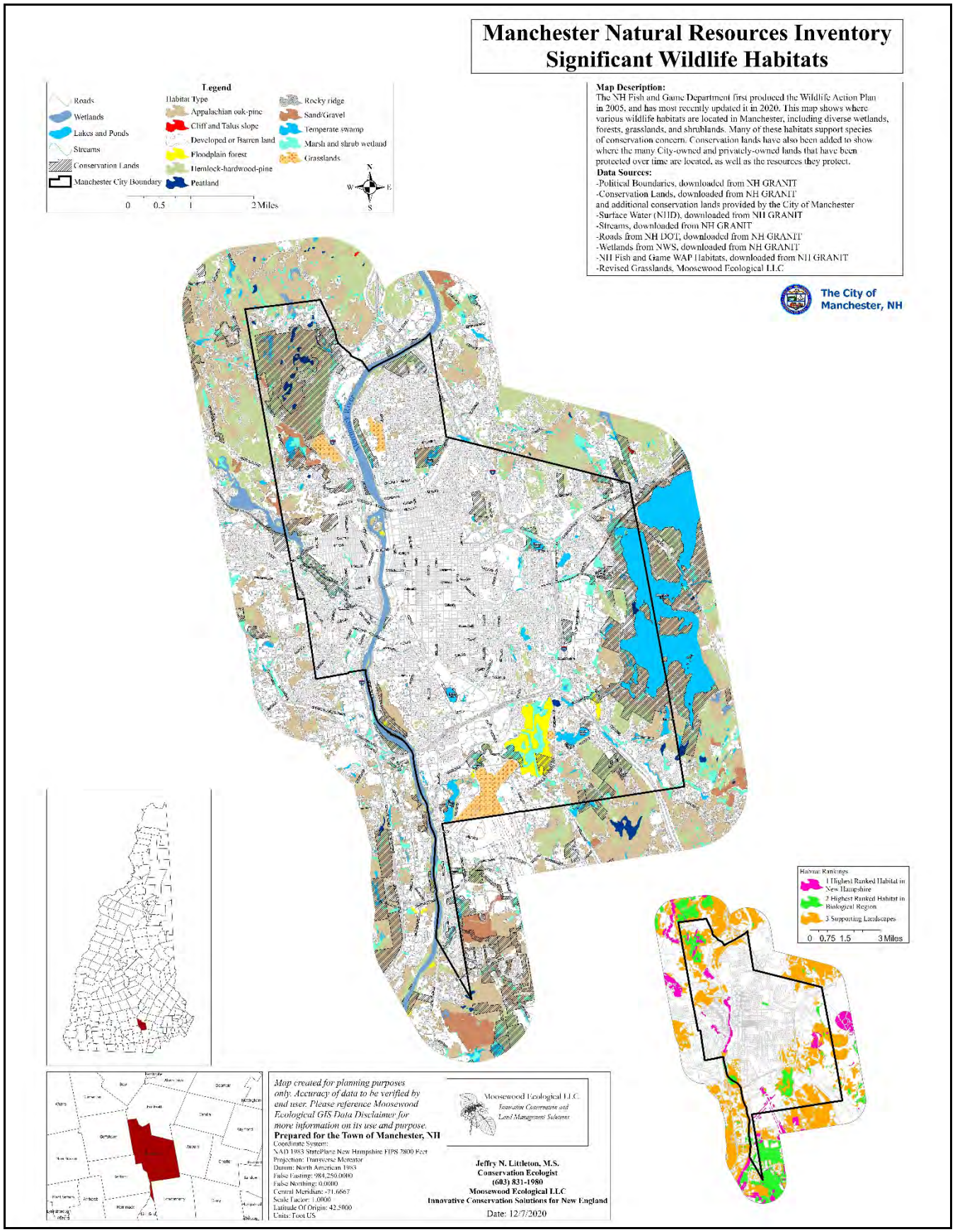

Figure 8 Significant wildlife habitats in Manchester.

Wildlife and Habitats

The following provides a brief account of selected site visits conducted on public properties. These site visits focused on documenting wildlife, habitats, and rare species and natural communities. Species listed in bold include rare species listed by the NH Wildlife Action Plan (2015) and NH Natural Heritage Bureau (2020). These include threatened and endangered species, as well as species of greatest conservation need. Exemplary natural communities are noted in *italics*.

Manchester Water Works

Properties owned by the Manchester Water Works surrounding the western side of Massabesic Lake provide diverse habitats for wildlife, including upland forests, swamps, marshes, ponds, shallow lakeshores, vernal pools, and turtles nesting sites. Uplands are dominated by mature forests of Appalachian oak and pine with small patches of hemlock, hardwoods, and pine and are characterized by a dense canopy and well-developed sapling and shrub understory. Wetland habitats include emergent marshes and shrub swamps along the lakeshore and several small, isolated wetlands throughout the forested habitat that may function as vernal pools. Massabesic Lake and Waterworks properties support numerous locations of two exemplary natural community systems, including the *sandy pond shore system* and *black gum-red maple basin swamp.*

Such diverse vegetative structure provides extensive niches for wildlife, as each species selects certain habitats and features for foraging, nesting, refuge, and territorial displays. **Scarlet Tanagers**, which are sensitive to habitat fragmentation, inhabit the interior forest, where they prefer the upper branches of tall deciduous trees for nesting, foraging, and singing. White-breasted Nuthatches also inhabit deciduous forests but are less selective and may be found along forest edges. This species nests in cavities and feeds on the tree bole or along branches. Ovenbirds, a type of warbler, nest and forage on the forest floor, relying on dense cover and their drab plumage to evade predators.

Table 5 lists bird species observed on three days from July 9 to October 1, and although far from a complete list of birds known to occur in the area, illustrates the variety of species supported by the array of habitats along the lake and adjacent uplands. Emergent

marshes support waterfowl and wading birds, including Wood duck, Mallard, and Great Blue Heron, as well as smaller species, such as Common Yellowthroat, Song Sparrow, Swamp Sparrow, Red-winged Blackbird, **Rusty Blackbird**, and Grackle. Mature forest provides breeding habitat for Baltimore Oriole, **Scarlet Tanager**, Eastern Wood Pewee, **Veery**, and Ovenbird. Dense, shrubby vegetation of edge habitats between uplands and wetlands attract a high diversity of birds, including Gray Catbird, **Eastern Towhee**, Eastern Tufted Titmouse, American Goldfinch, and Northern Flicker.

All the species listed below are relatively common and widespread, with the exception of **Rusty Blackbirds**, which were observed in a mixed migratory flock of grackles and red-winged blackbirds in October. **Rusty Blackbirds** are a Species of Concern in New Hampshire and in many parts of their range due to drastic population declines over the past several years. The presence of this large migrating flock indicates the importance of the marshes and other habitats along the lake for wildlife throughout the year.

In addition to the rare species noted above, Massabesic Lake, Waterworks' properties, and adjacent properties support at least 10 known species of plants and wildlife. These include one species of fish, two species of reptiles, three species of birds, three species of plants, and one species of dragonfly. It is anticipated that additional rare species and natural communities occur in this special area of interest.

Table 5 Bird species observed on Massabesic Lake and adjacent lands, July – October, 2020.

Mallard	Black-capped Chickadee	Swamp Sparrow
Mourning Dove	Eastern Tufted Titmouse	**Eastern Towhee**
Gulls (probably Ring-billed)	Red-breasted Nuthatch	Baltimore Oriole
Double-crested Cormorant	White-breasted Nuthatch	Red-winged Blackbird
Great Blue Heron	Carolina Wren	**Rusty Blackbird**
Cooper's Hawk	Gray Catbird	Common Grackle
Red-bellied Woodpecker	Northern Mockingbird	Ovenbird
Northern Flicker	**Veery**	Common Yellowthroat
Peregrine Falcon	American Robin	Pine Warbler
Eastern Wood Pewee	American Goldfinch	**Scarlet Tanager**
Red-eyed Vireo	White-throated Sparrow	Northern Cardinal

Figure 9 A view of Massabesic Lake from the Manchester Water Works property. A variety of waterfowl (e.g., ducks, geese, mergansers), wading birds (e.g., herons, egrets), and shorebirds (sandpipers), and loons.

Figure 10 This turtle nesting area was observed near Massabesic Lake. A predator, such as a fox or racoon, excavated the nest and ate the contents of the eggs. The red arrow indicates the nest and the yellow arrow shows the shell of the depredated egg.

Cohas Brook and Cohas Great Swamp

Surveys completed along Cohas Brook included two roadside visits and one field survey of the floodplain along the west side of Mammoth Road. The floodplain west of Mammoth Road is a flat, densely vegetated plain bordering a deep, meandering reach of Cohas Brook. From a large open field on the west side of Mammoth Road, the terrain drops slightly into a dense, mature hardwood forest with scattered white pine. The understory is extremely dense, especially along the boundaries of the field to the east and the channel to the west, and is comprised of ferns, nettles, grasses, sedges, shrubs, and vines. There are scattered invasive plants, including multiflora rose and Japanese barberry. The area between the forested habitat and the channel is extremely densely vegetated with tall grasses and shrubs. A few birds were observed during the survey, including American Goldfinch, American Robin, and a pair of Red-tailed Hawks, which were likely nesting in the vicinity.

The roadside surveys occurred along Rt. 28 A in the southeastern corner of Manchester and along Rt. 28 just north of the airport. In both locations, the entire drainage appeared heavily vegetated with cattails, Phragmites, and shrubs. Along Rt. 28, multiflora rose and Asian bittersweet grew densely among other trees and shrubs. The channel has been altered and severely restricted at the Rt. 28 A site, from the under-sized culvert leading under Rt. 28 A through the parking lot on the west side of the road, where the stream channel has been redirected into a ditch that leads north, then west along the edge of the parking lot before flowing into the Great Cohas Swamp wetland complex on the northwest end of the lot. Under-sized culverts, altered channels, invasive plant infestations, and encroaching development have severely damaged these sections of Cohas Brook and its tributaries.

Known rare species associated with Cohas Brook, Great Swamp, and adjacent properties include two species of reptiles, one species of fish, one bird species, and two species of plants. Also, two locations of the exemplary seasonally flooded red maple swamp are located in this area. It is anticipated that additional rare species and natural communities occur in this special area of interest.

Rock Rimmon Park

The ledges and rock outcropping associated with Rock Rimmon were explored to examine the current condition of the exemplary natural communities and rare species previously documented on the site. There are two exemplary natural community systems known to occur on Rock Rimmon. These include the *temperate ridge-cliff-talus system* and the *pitch pine-Appalachian oak-heath forest community*. These exemplary sites have been subject to intense human land uses such as graffiti, litter, encampments, and unsanctioned trails. The level of human presence and its lasting affects has negatively impacted these rare elements. As such, these will most likely be removed from exemplary status unfortunately.

In addition, there are seven known rare species that were previously documented at Rock Rimmon. These included six species of plants and one reptile. No rare species were observed during the site visit. Common wildlife species observed included downy woodpecker, eastern wood-pewee, blue jay, American crow, chickadee, and white-breasted nuthatch. Invasive plants included Asiatic bittersweet, glossy buckthorn, and bush honeysuckle.

Figure 11 Graffiti on top of Rock Rimmon has a lasting human presence that has diminished the ecological significance of this exemplary natural community system.

Figure 12 The exemplary *pitch pine-Appalachian oak-heath forest* community has been impacted by at least one encampment, litter, and unsanctioned trails. Otherwise, the forest is in good condition given its proximity to residential developments and human use.

Piscataquog River Park

The Piscataquog River Park boasts over 112 acres of conserved City-owned properties, providing natural habitat buffers to help protect the water quality of the river, as well as offering numerous walking trails and access for fishing and swimming. The bridge linking the fields and forests on the east side to the rail trail and forests on the west side provides an outstanding viewpoint of the Piscataquog River. It appears that this park is heavily used on a regular basis.

The dynamic nature of the river and the open water created by damming upstream, in combination with the adjacent upland forests and wetlands, have made this area ecologically significant. It is expected to have relatively high biodiversity within the City based on habitat availability. A variety of birds were documented, including mallard, bald eagle, blue jay, American crow, mourning dove, eastern wood-pewee, hairy woodpecker, red-bellied

woodpecker, tufted titmouse, American robin, gray catbird, **wood thrush**, common yellowthroat, black-throated green warbler, cardinal, **scarlet tanager**, and song sparrow. Five species of mammals were observed by sight or tracks, including a bat flying over the river, woodchuck, coyote, red fox, and racoon. A garter snake was also observed. In addition, there are seven rare species associated with or directly adjacent to the park, including one reptile, three species of plants, one butterfly, one moth, and one mussel. It is expected that additional rare species are present, as well as significant natural communities.

This park has a moderate to high level of invasive plants, particularly along forest edges and along the riverbank. Species included multi-flora rose, glossy buckthorn, Asiatic bittersweet, Norway maple, Japanese knotweed, and autumn olive.

Figure 13 A spectacular view of the Piscataquog River from the pedestrian bridge.

Blodgett Park

Blodgett Park covers nearly 45 acres of protected City lands along Black Brook. This area has a rich human history, including ice harvesting, skating, hockey, fishing, swimming, and picnicking. Black Brook was dammed in the early 1900s, but the dam has since been removed, restoring critical habitat connectivity for a variety of aquatic species. Most of the property is not accessible, as the only parking area is located off Front Street to access a short trail along Black Brook.

Black Brook provides habitat for a variety of aquatic species, such as fish and macroinvertebrates. Its associated wetlands are great for amphibians, reptiles, birds, and mammals. The upland forests provide a natural buffer against the surrounding built environment, helping to reduce sedimentation and toxic runoff from nearby roads, parking lots, and other developments. Wildlife observed included chipmunk, gray squirrel, red fox, mourning dove, hairy woodpecker, blue jay, American robin, chickadee, common yellowthroat, indigo bunting, and red-winged blackbird. Many den sites were noted along the stream bank that provides resting and denning sites for various mammals, including fox, otter, and mink. One rare fish species was previously documented in Black Brook. Invasive plants included glossy buckthorn, Asiatic bittersweet, burning bush, and Japanese barberry.

Figure 14 One of several den sites observed along Black Brook.

Figure 15 Black Brook provides a wealth of wildlife habitat, including its numerous wetlands and adjacent forests.

Manchester Cedar Swamp

The Manchester Cedar Swamp and Hackett Hill is another ecologically significant area in the City. These two sites are located in the northwest part of Manchester and cover approximately 1,027 acres. It comprises one of Manchester's largest natural areas fully stocked with a rich array of habitats for biologically diverse plant and wildlife communities, including many rare species and natural communities.

Upland forests include an array of hemlock-hardwood pine forest and Appalachian oak-pine forest. Various wetlands are scattered throughout the area, including forested and shrub swamps, vernal pools, marshes, and open water, as well as a few headwater streams. Many of these wetlands have been ranked as exemplary. These include the *Atlantic white cedar-giant rhododendron swamp*, *coastal conifer peat system*, *black spruce swamp*, and *black gum-red maple basin swamp*.

Wildlife observed during site visits included great blue heron, sharp-shinned hawk, blue jay, American crow, cedar waxwing, chickadee, white-breasted nuthatch, **veery**, **wood**

thrush, red-eyed vireo, ovenbird, pine warbler, black-throated green warbler, black-throated blue warbler, and red-winged blackbird. Other species noted included **moose**, deer, coyote, and chipmunk. In addition, there have been at least six rare species documented in this area or directly adjacent to it, including four species of plants, one fish, and one dragonfly.

Figure 16 The *Atlantic white cedar-giant rhododendron swamp* is a globally rare natural community. This is an exemplary version of this community, which can be viewed from a boardwalk trail. A good time to visit the swamp is in June when the rare giant rhododendron is blooming.

Wildlife Action Plan Highest Ranked Habitat by Condition

With the goal of setting priorities for conservation of important wildlife habitat in New Hampshire, the Wildlife Action Plan also identified areas of the state with unusually pristine, influential, diverse, or extensive examples of "exemplary" habitat. These areas were, in turn, ranked by condition on both sub-state regional and statewide levels, resulting in a tiered ranking of priority areas for conservation. The inset map in Figure 8 (located on page 23) illustrates this rank-mapping of priority areas for conservation in Manchester.

Purple and green color-coded areas indicate highest ranked habitats by condition, both within New Hampshire (purple) and within an ecoregion (green). These include the central section of the Merrimack River, the northwest section of Manchester including and adjacent to the Manchester Cedar Swamp Preserve, parts of the airport, Cohas Swamp, and a section of the Manchester Water Works property. The extensive matrix of highest ranked habitats is surrounded by large areas of "Supporting Landscape." Supporting Landscapes (in orange) provide important habitat of local importance. All three categories are considered unusually significant for wildlife, and especially important areas for land conservation.

Documented Rare Elements in Manchester

Numerous rare and uncommon plant and animal species have been documented over the years in Manchester, and these data are maintained by the New Hampshire Natural Heritage Bureau (NHB) of the NH Division of Forests and Lands, in cooperation with the New Hampshire Fish & Game's Nongame and Endangered Wildlife Program. Generalized information on the presence of these species and communities is available from the NHB by municipality. According to the Bureau's "Rare Plants, Rare Animals and Exemplary Natural Communities in New Hampshire Towns" (2019), the species and natural communities/systems listed in Table 6 below have been documented to exist in the City in the last 20 years. However, there are numerous other rare documentations that are considered as "historical" in the NHB database, having been last observed more than 20 years ago. These species may still be present, but additional surveys would be needed to confirm these historical accounts.

Table 6 Rare species and natural systems documented in Manchester.

Rare Elemental Occurrence	Rarity Rank NH	US
Natural Communities		
Pitch pine-Appalchian oak-heath forest**	N/A	
Temperate ridge-cliff-talus system*	N/A	
Atlantic white cedar-giant rhododendron swamp***	N/A	
Black gum-red maple basin swamp**	N/A	
Black spruce swamp**	N/A	
Coastal conifer peat swamp system**	N/A	
Sandy pond shore system**	N/A	
Plants		
Bird-foot violet**	T	
Clasping milkweed**	T	
Clustered sedge*	T	
Coastal plain grass-leaved goldenrod*	T	
Common star-grass**	T	
Downy false foxglove**	E	
Giant rhododendron***	T	
Licorice goldenrod**	T	
Long-spined sandbur**	E	
Narrow-leaved white-topped aster**	E	
Quill-leaved arrowhead***	E	
River birch*	T	
Small whorled pogonia**	T	T
Wild lupine**	T	
Wright's spikesedge***	E	
Mammals		
New England cottontail***	E	
Birds		
Bald eagle**	SC	
Common loon**	T	
Eastern meadowlark**	T	
Grasshopper sparrow**	T	
Peregrine falcon**	T	
Vesper sparrow**	SC	
Reptiles		
Blanding's turtle**	E	
Eastern hognose snake**	E	
Northern black racer**	T	
Fish		
American eel**	SC	
Banded sunfish**	SC	
Redfin pickerel**	SC	
Butterflies and Moths		
Pine barrens Zanclognatha moth**	SC	
Pygmy snaketail**	no rank	
Rapids clubtail***	SC	
Ringed boghaunter***	E	
Skillet clubtail***	SC	

Source: NH Natural Heritage Bureau database (July 2020).

E - Endangered

T - Threatened

SC - Special Concern

* - High Importance

** - Very High Importance

*** - Extremely High Importance

The specific location and extent of these rare species and communities have not typically been available for this type of study due to data release policies of the NH Division of Forests and Lands which houses the NHB. However, a recent data sharing release policy has allowed for site-specific Natural Heritage data to be accessed for use in developing conservation focus areas and land use planning. The agreement does not allow for graphic display of or references to specific locations, but these data have been incorporated into the conservation priorities analysis as an importance factor in determining conservation focus areas.

The geological, glacial, and fluvial history of the Merrimack River, and two others that flow into it from the east and west side of the river - Piscataquog River and Cohas Brook - has resulted in the formation and development of a diverse suite of natural habitats and communities. The artifacts of the ancient glacial lake Merrimack, including large deposits of sand and gravel near the river, have been reworked by the river and various tributary streams to create steep bluffs and ravines, as well as floodplain terraces. These landforms provide conditions unlike those elsewhere in Manchester, which is otherwise characterized by rolling hills blanketed by glacial tills on the outskirts of the City, with some small areas of outwash sediments.

Five exemplary wetland plant systems and natural communities have been documented in Manchester. Four of these – *Atlantic white cedar-giant rhododendron swamp*, *black gum-red maple basin swamp*, *black spruce swamp*, and *coastal conifer peat swamp system* – can be observed at the Manchester Cedar Swamp Preserve. There are two exemplary terrestrial plant communities that can be observed at Rock Rimmon Park. These include *pitch pine-Appalachian oak-heath forest community* and *temperate ridge-cliff-talus system*. However, due to extreme human disturbance (e.g., litter, graffiti, erosion, human encampments, etc.) these sites may no longer be considered as exemplary by the NHB due to misuse and habitat degradation. Area polygons are derived by the NH Natural Heritage Bureau for each mapped record of a species or community, based on actual observation points, degree of confidence regarding actual location and extent, knowledge of the biology or ecology of an element, and the extent of suitable habitat. The mapped location and extent of

these elements are one basis for the delineation of conservation priority areas that would protect these resources.

There are 18 known species of rare wildlife that have been documented throughout Manchester over the past 20 years. These include 1 mammal, 6 species of birds, 3 species of reptiles, 3 species of fish, and 5 species of butterflies and moths. The various wetlands in Manchester are very significant for numerous rare turtles, birds, and butterflies/moths. Certain terrestrial habitats are significant for rare snakes, and grasslands provide a declining habitat important for three species of rare grassland birds.

A total of 15 State-threatened and endangered plants have been documented within the past 20 years in Manchester. These species are associated with wetlands, riverbanks, and upland forests. The Federally-threatened orchid species small-whorled pogonia has also been documented at one location in Manchester. A GIS species distribution model developed by NatureServe specifically for this species across its range was referenced during the field surveys in hopes of targeting additional populations.

Figure 17 This globally rare *Atlantic white cedar – giant rhododendron swamp* attests to the significance of Manchester's biological heritage. The public can explore this rare natural community along with many other fascinating features at the Manchester Cedar Swamp, which is owned and managed by The Nature Conservancy.

Unfragmented Lands and Habitat Connectivity

Unfragmented lands are relatively large blocks of forests and other ecological communities within areas of human infrastructure (roads and developed areas) that are not bisected by maintained roads. Fragmentation of natural landscapes by roads and associated development can negatively affect wildlife populations in various ways, from reducing habitat quality and availability to causing direct mortality on roads. Increased predation and nest parasitism along edges of smaller blocks of habitat result in diminished breeding success, and may lead to species loss altogether. The degree of severity of fragmentation depends upon many aspects, such as the size and shape of unfragmented blocks, the species or natural community in question, the extent of loss of natural habitats, intensity of human use, and colonization of invasive species.

The NH Wildlife Action Plan (WAP) developed an unfragmented lands analysis. However, this data layer has inherent errors due to the incorrect classification of roads as being a fragmenting feature. As such, the unfragmented lands were refined to more accurately reflect Manchester's landscape (Figure 18). For the purposes of this project, fragmenting features were defined as 500 feet on either side of existing roadways, including all state and town roads but excluding Class VI roads and trails, as well as private driveways. This assumes that most development occurs within 500 feet of roadways.

Large blocks of unfragmented areas are widely known to support greater biodiversity than smaller blocks. They include a variety of natural habitats such as forests, wetlands, streams, and ponds, but also can include human-modified areas such as agricultural lands and shrublands. As unfragmented areas become smaller due to the construction of roadways and developments, their biodiversity generally decreases. This fragmentation effect has less immediate impact on generalist species or those with small home ranges (such as gray squirrel, raccoon, many amphibians, and small rodents) while affecting and potentially eliminating area-sensitive specialists that need large forested blocks in order to maintain their home ranges and for long-term survival (such as bear, bobcat, moose, various reptiles, wood thrush, and goshawk). Appendix B provides a general list of habitat block size requirements for wildlife to help illustrate this point.

Large unfragmented landscapes also allow wildlife to move among critical feeding, breeding, nesting, and overwintering habitats, and to migrate to new territories. Maintaining connectivity between critical habitats can provide permanent wildlife corridors within the built environment, enabling wildlife populations to survive.

Wildlife must be able to travel safely throughout the landscape to meet their biological needs. Many depend upon a variety of habitats for their survival and may utilize many natural features for travel. These include features such as riparian zones of wetlands, ponds and streams, ridgelines, utility rights-of-way, and forest patches acting as a safe route between two or more habitats. A variety of wildlife can be associated with these corridors, including otter, muskrat, fox, coyote, bobcat, deer, moose, fisher, mink, and bear.

Wildlife corridors are not only significant for mammals but equally as important for amphibians, reptiles, and migratory birds. Both amphibians and reptiles begin to move from their wintering habitats to their respective breeding and nesting grounds in the spring. This is the time of year that most mortality can be noticed as these species travel across roadways in search of suitable habitats. This affect can often be exacerbated as the same individuals must return to their wintering habitats. Thus, there is a great significance in maintaining habitat connectivity, as well as understanding where these patterns of movement are taking place. This latter point can be an especially important tool for community education and awareness about corridors across roadways. It can provide a means to adjust transportation patterns to help eliminate potential road mortality or identify sites for road modifications to allow wildlife to safely cross.

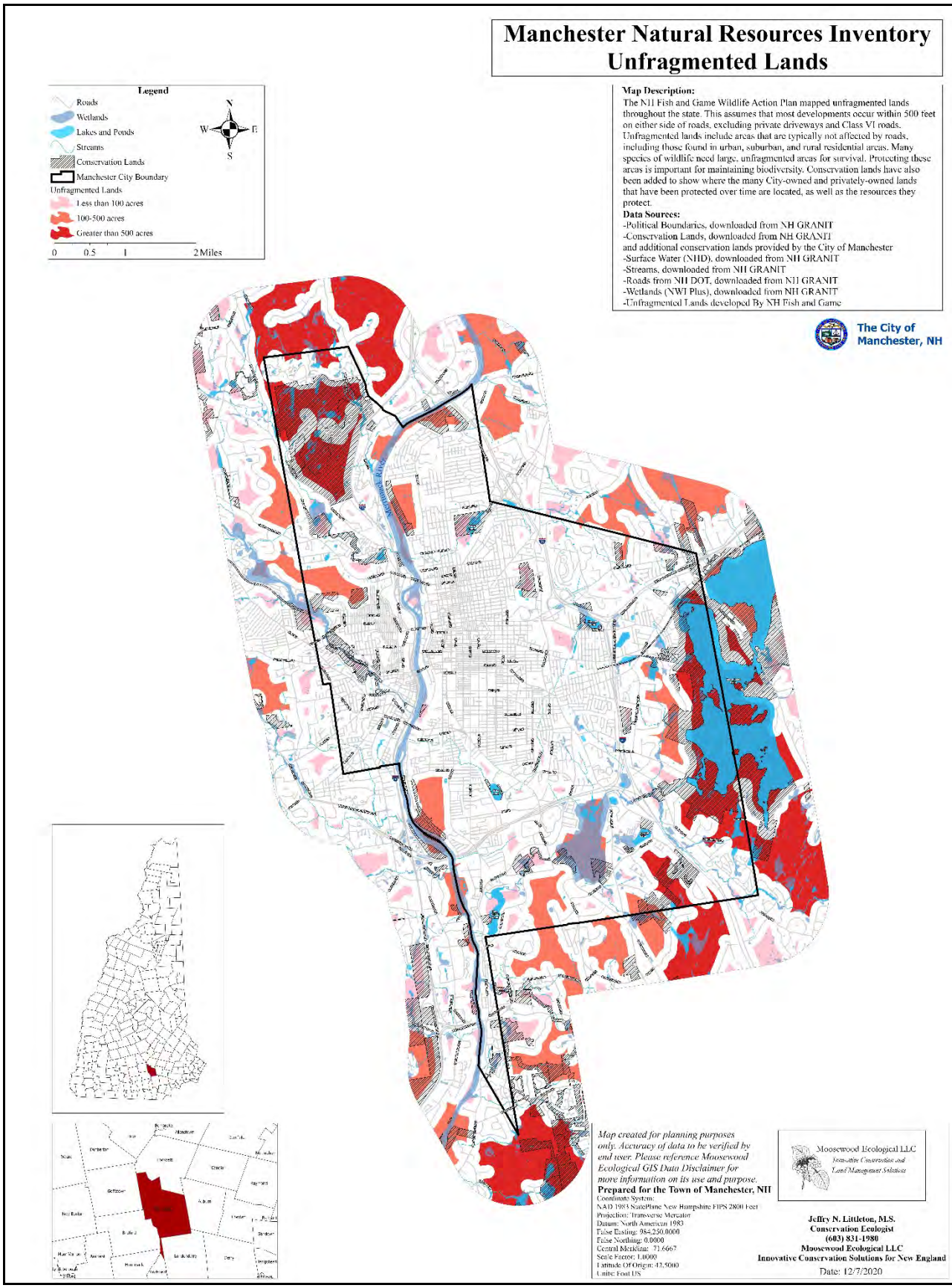

Figure 18 Unfragmented lands in Manchester.

Invasive Species

Invasive species are defined as non-native species that have been introduced to our continent over time and have demonstrated a tendency to reproduce and spread widely, often to the detriment of our native species. They possess many traits that provide them with a competitive edge, including the production of numerous offspring, adaptation to a variety of site and soil conditions, thrive in areas of disturbance, and early, rapid development in the spring.

Cygan (2011) further explains, "These traits allow invasive species to be highly competitive and, in many cases, suppress native species. Studies show that invasives can reduce natural diversity, impact endangered or threatened species, reduce wildlife habitat, create water quality impacts, stress and reduce forest and agricultural crop production, damage personal property, and cause health problems."

Many of our invasive plants have been brought here for many uses such as ornamental components of landscaping, erosion control, and food for native wildlife. Many other invasive species, including plants, insects, and fungi, were brought to North America inadvertently through shipments of various products from other continents. Historically, this resulted in the demise of American chestnuts and elms, as well as the beech bark scale disease that reduces this species rigor and causes death. Currently, we are dealing with many other pathogens that are affecting our forests, including emerald ash borer, hemlock wooly adelgid, Asian long-horned beetle, and red pine scale.

As with most communities in New Hampshire, Manchester has certain areas that have a strong presence of invasive plants while other areas may have relatively low to no pressure. Edges of natural habitat including shorelines and road frontage, powerlines, recently logged areas, old farm fields, and abandoned buildings and properties are especially likely to have invasive plant species, as we found in Manchester. Invasive plants were observed in all locations visited in 2020, as well as along roadsides. See the accounts from site visits above to better understand species distribution in the City.

Most wetlands had purple loosestrife, Japanese knotweed, and/or phragmites. Aquatic invasive plants include variable milfoil and Brazilian waterweed found in the Merrimack River and variable milfoil and fanwort observed in Massabesic Lake. Typical upland invasive

plants observed included Japanese knotweed, Asiatic bittersweet, glossy buckthorn, Japanese barberry, multi-flora rose, burning bush, Norway maple, autumn olive, and bush honeysuckles. Other invasive species are likely present throughout Manchester in both terrestrial and wetland habitats.

Figure 19 This wetland along South Mammoth Road near Manchester's southern boundary is loaded with a dense patch of phragmites along with purple loosestrife. The level of abundance of these two invasive species does not make it practical for restoration.

AGRICULTURAL AND FOREST RESOURCES

Important Agricultural Soils

In response to the Farmland Protection Policy Act of 1981[3], agricultural soils were mapped by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Based on a variety of physical and chemical properties (i.e., drainage, texture, hydric regime, pH, erodibility factor), these soils have been identified as being among the most productive lands for many types of farming practices. These include prime farmland soils, farmland soils of statewide importance, and farmland soils of local importance. Each is defined below by the USDA NRCS:

Prime Farmland

- Soils that have an aquic or udic moisture regime and sufficient available water capacity within a depth of 40 inches to produce the commonly grown cultivated crops adapted to New Hampshire in 7 or more years out of 10.
- Soils that are in the frigid or mesic temperature regime.
- Soils that have a pH between 4.5 and 8.4 in all horizons within a depth of 40 inches.
- Soils that have either no water table or have a water table that is maintained at a sufficient depth during the cropping season to allow cultivated crops common to New Hampshire to be grown.
- Soils that have a saturation extract less than 4 mmhoc/cm and the exchangeable sodium percentage is less than 15 in all horizons within a depth of 40 inches.
- Soils that are not frequently flooded during the growing season (less than a 50% chance in any year or the soil floods less than 50 years out of 100.)
- The product of the erodibility factor times the percent slope is less than 2.0 and the product of soil erodibility and the climate factor does not exceed 60.
- Soils that have a permeability rate of at least 0.06 inches per hour in the upper 20 inches.

[3] As defined by the USDA NRCS: "The Farmland Protection Policy Act of 1981 was established to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses.

- Soils that have less than 10 percent of the upper 6 inches consisting of rock fragments larger than 3 inches in diameter.

Farmland of Statewide Importance

These soils refer to land that is not prime or unique but is considered farmland of statewide importance for the production of food, feed, fiber, forage and oilseed crops. Criteria for defining and delineating farmland of statewide importance are determined by a state committee chaired by the Commissioner, New Hampshire Department of Agriculture, Markets and Food, with members representing the University of New Hampshire Cooperative Extension, New Hampshire Association of Conservation Districts and the New Hampshire Office of State Planning. The NRCS State Soil Scientist serves on this committee in an advisory capacity. The original criteria were established on June 20, 1983. It was updated on December 7, 2000.

Soils of statewide importance are soils that are not prime or unique and:

- Have slopes of less than 15 percent
- Are not stony, very stony or bouldery
- Are not somewhat poorly, poorly or very poorly drained
- Includes soil complexes comprised of less than 30 percent shallow soils and rock outcrop and slopes do not exceed 8 percent.
- Are not excessively drained soils developed in stratified glacial drift, generally having low available water holding capacity.

Farmland of Local Importance

Farmland of local importance is farmland that is not prime, unique or of statewide importance, but has local importance for the production of food, feed, fiber and forage. Criteria for the identification and delineation of local farmland are determined on a county-wide basis by the individual County Conservation District Boards. The original criteria were established on June 20, 1983. Updates are noted according to the county

initiating the update. The criteria for soils of local importance in Manchester are as follows:

- Soils that are poorly drained, have artificial drainage established and are being farmed.
- Specific soil map units identified from the NRCS county soil survey legend, as determined by the Conservation District Board.

The Natural Resources Conservation Service reports that important agricultural soils cover approximately 4,818 acres, or roughly 22% of Manchester (Table 7 and Figure 20). However, these data do not reflect the areas that have been developed, and therefore important agricultural soils occupy much less of an area. Prime farmland soils make up about 0.3% of the total acreage of agricultural soils, while farmlands of local and statewide importance represent roughly 21% of these soils.

Table 7 Summary of important soils for farm production in Manchester.

Important Soil Type	Size (acres)	% of City
Prime Farmland Soils	74.1	0.3%
Farmland Soils of Statewide Significance	1,208.5	5.4%
Farmland Soils of Local Significance	3,535.6	15.8%

SOURCE: USDA Natural Resources Conservation Service soils (2009).

Other important agricultural resources include active farmlands. Aerial photography interpretation revealed four areas as active agriculture in Manchester. These included hayfields. These sites should be field checked for accuracy and to add other active farmlands.

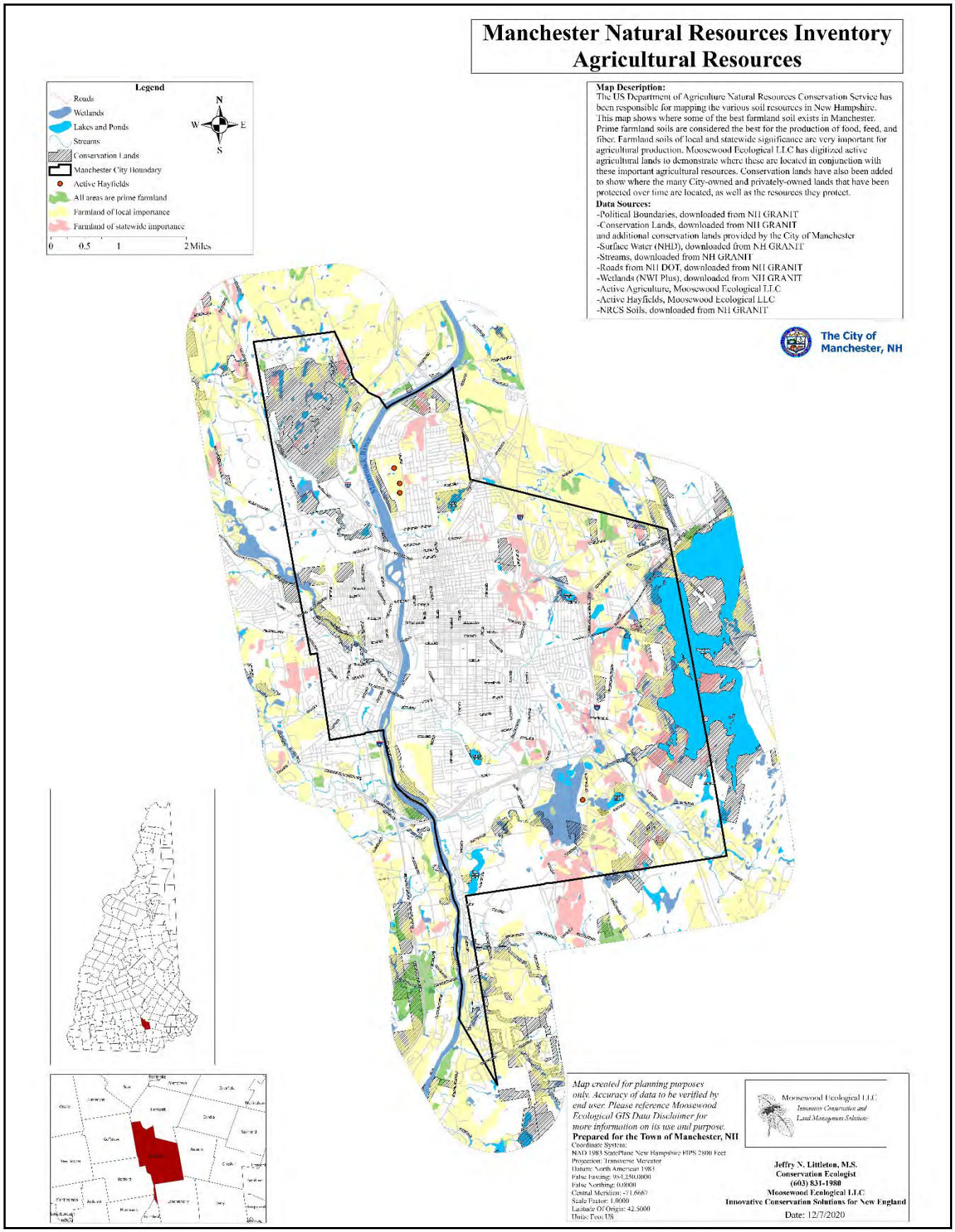

Figure 20 Agricultural resources in Manchester.

Important Forest Soils

Forest resources within New Hampshire are significant for many reasons. They provide a multitude of forest products, clean air, substantial habitats for wildlife and plants, recreation and tourism opportunities, and sources of employment. They also promote local economies, mitigate the effects of climate change, and provide diverse ecological functions (such as nutrient cycling, carbon sequestration, and water quality maintenance through sediment trapping). For these reasons, it is important to maintain large tracts of forests and to better understand where important and undeveloped forest soils exist in Manchester.

The USDA NRCS has mapped the distribution of important forest soils and has classified them according to their capacity to grow trees. These soils signify areas as providing the most productive lands for timber production. The NRCS has identified three soils groups within this category and have described each as follows:

Forest Soil Class IA

This group consists of the deeper, loamy textured, moderately well, and well-drained soils. Generally, these soils are more fertile and have the most favorable soil moisture relationships. The successional trends on these soils are toward stands of shade tolerant hardwoods, i.e., beech and sugar maple. Successional stands frequently contain a variety of hardwoods such as red oak, beech, sugar maple, red maple, white birch, yellow birch, aspen, and white ash in varying combinations with red spruce, hemlock, and white pine. Hardwood competition is severe on these soils. Softwood regeneration is usually dependent upon persistent hardwood control efforts.

Forest Soil Class IB

The soils in this group are generally sandy or loamy over sandy textures and slightly less fertile than those in group IA. These soils are defined as either moderately well-drained or well-drained. Soil moisture is adequate for good tree growth, but may not be quite as abundant as in group IA soils. Soils in this group have successional trends toward a climax of tolerant hardwoods, predominantly beech. Successional stands,

especially those which are heavily cutover, are commonly composed of a variety of hardwood species such as red oak, red maple, aspen, paper birch, yellow birch, sugar maple, and beech, in combinations with white pine, red spruce, balsam fir, and hemlock. Hardwood competition is moderate to severe on these soils. Successful softwood regeneration is dependent upon hardwood control.

Forest Soil Class IC

The soils in this group are outwash sands and gravels. Soil drainage is typically found to range between somewhat excessively to excessively well-drained, but can be moderately well-drained. Soil moisture is adequate for good softwood growth, but is limited for hardwoods. White pine, red maple, aspen, and paper birch are common in early and mid-successional stands. Successional trends on these coarse-textured, somewhat droughty, and less fertile soils are toward stands of shade tolerant softwoods, i.e., hemlock and red spruce. Hardwood competition is moderate to slight on these soils. Due to less hardwood competition, these soils are ideally suited for softwood production. With modest levels of management, white pine can be maintained and reproduced on these soils. Because these soils are highly responsive to softwood production, especially white pine, they are ideally suited for forest management.

The Natural Resources Conservation Service reports that important forest soils represent nearly 9,288 acres, or approximately 42% of Manchester (Table 8 and Figure 21). However, this data does not reflect the areas that have been developed, and therefore important forest soils occupy much less of an area. Forest soil groups IA and IB make up the majority of this resource and are most ideally suited for hardwood production. Soil group IC appears to be more restricted to stream drainages where outwash sands and gravels were deposited by glacial activity about 11,000 years ago.

Table 8 Summary of important forest soils for timber production in Manchester.

Important Soil Type	Size (acres)	% of City
Hardwood Production (Groups IA and IB)	6,174.6	27.6%
Softwood Production (Group IC)	3,113.2	13.9%

SOURCE: USDA Natural Resources Conservation Service soils (2009).

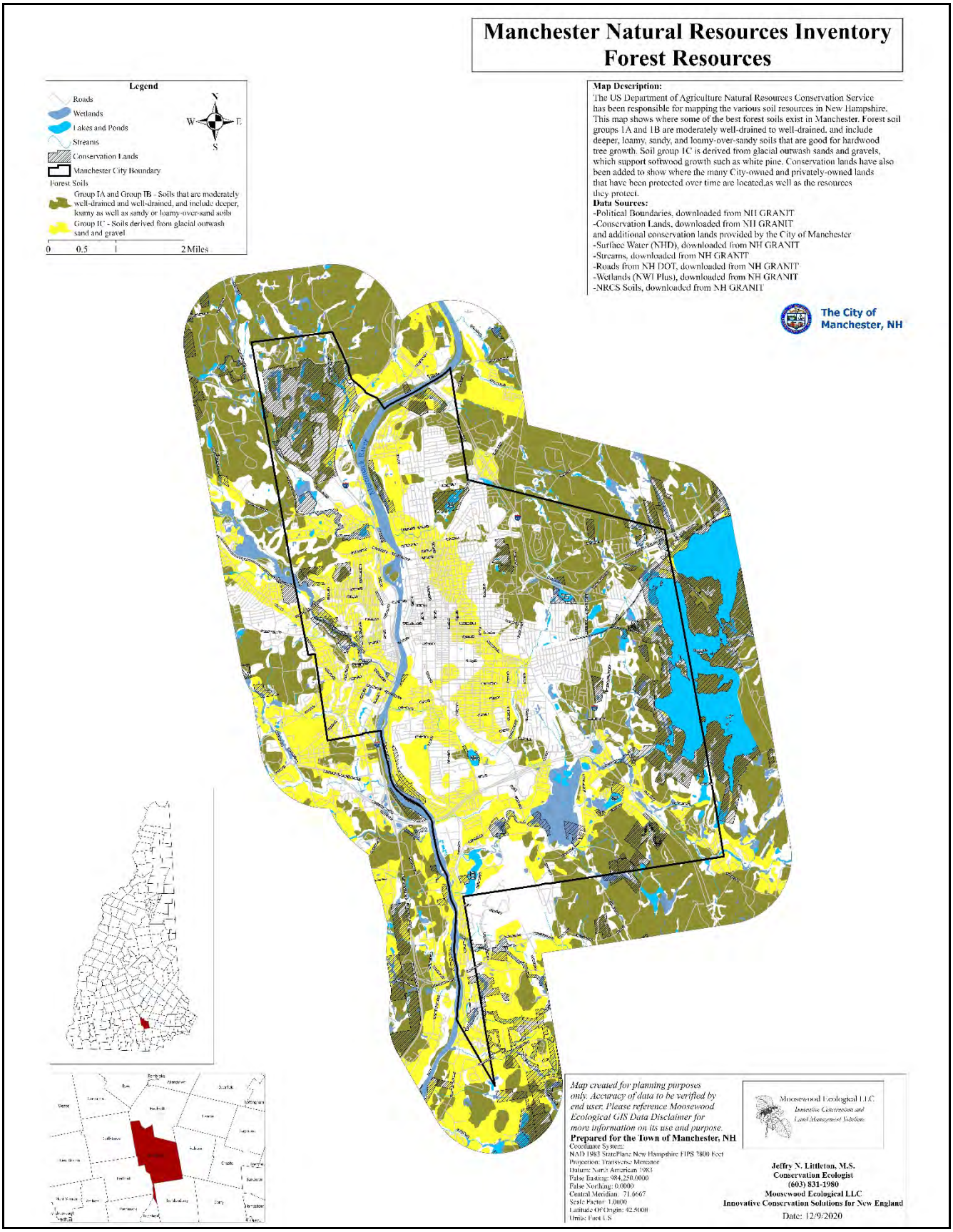

Figure 21 Forest resources in Manchester.

CONSERVATION AND PUBLIC LANDS

Conservation easements and ownership by public entities help to protect open space, natural resources, and traditional land uses. These lands will remain undeveloped and in their natural state, often in perpetuity, to support important environmental and/or aesthetic functions. Some may also be used for agriculture, forestry, and/or outdoor recreation. Either way, they ensure the continued functioning of natural processes, support the continuance of traditional uses, and the access to recreational resources that are essential to sustaining Manchester's character and quality of life.

The authors reviewed existing sources of mapped conservation lands, including the NH GRANIT database and input from the Manchester Planning and Community Department. Numerous conservation parcels were added to those provided by NH GRANIT. Each parcel was assigned to one of two protection codes based on the nature of the ownership and conservation protection of the parcel. A dataset of parcels with some sort of conservation restrictions, including conservation easements, was produced and is displayed in each map as a base layer.

Manchester's updated conservation and public lands are displayed in Figure 23. The history, nature, method, and parties involved with "conservation" in Manchester are highly variable. A number of parcels are protected with legally binding conservation restrictions, including conservation easements held by a variety of non-governmental organizations. A number of City-owned parcels are not specifically protected by legal restrictions, but have a history of traditional open space uses, and these are included as conservation lands. The final conservation lands dataset is inclusive of not only natural open space areas, but also public lands that have a variety of active outdoor uses. Each parcel was assigned a code representing the nature of the conservation level, including type of protection and a brief description of each (Table 9).

Based on the new conservation and public lands mapping, Manchester has a total of 3,941.7 acres of conservation open space. This represents nearly 18% of the total area of the City. By way of comparison, the combined five boroughs of New York City have about 21% of area within the municipal corporate boundary devoted to open space uses.[1] Table 10 below shows total acreages of conservation lands in Manchester by protection type.

[1] 2017 City Park Facts. The Trust for Public Lands.

Table 9 Descriptions of land conservation types in Manchester.

Code	Protection Type	Description
CE	Conservation Easement	Legal conservation restrictions enforced by an agency or land trust
FO	Fee Ownership	Property held in fee by a municipality, land trust, or agency as conservation land (may also have an easement)

Table 10 Conservation lands in Manchester by type and acreage.

Protection Type	Acres
Conservation Easement	833.6
Fee Ownership	3,108.1

SOURCE: GRANIT Conservation Lands database (2018) and City of Manchester (2020)

Figure 22 Massabesic Lake serves as Manchester's major source of drinking water and affords various conservation benefits in order to help protect water quality. This panaramic picture views across an emergent marsh with the lake in the background.

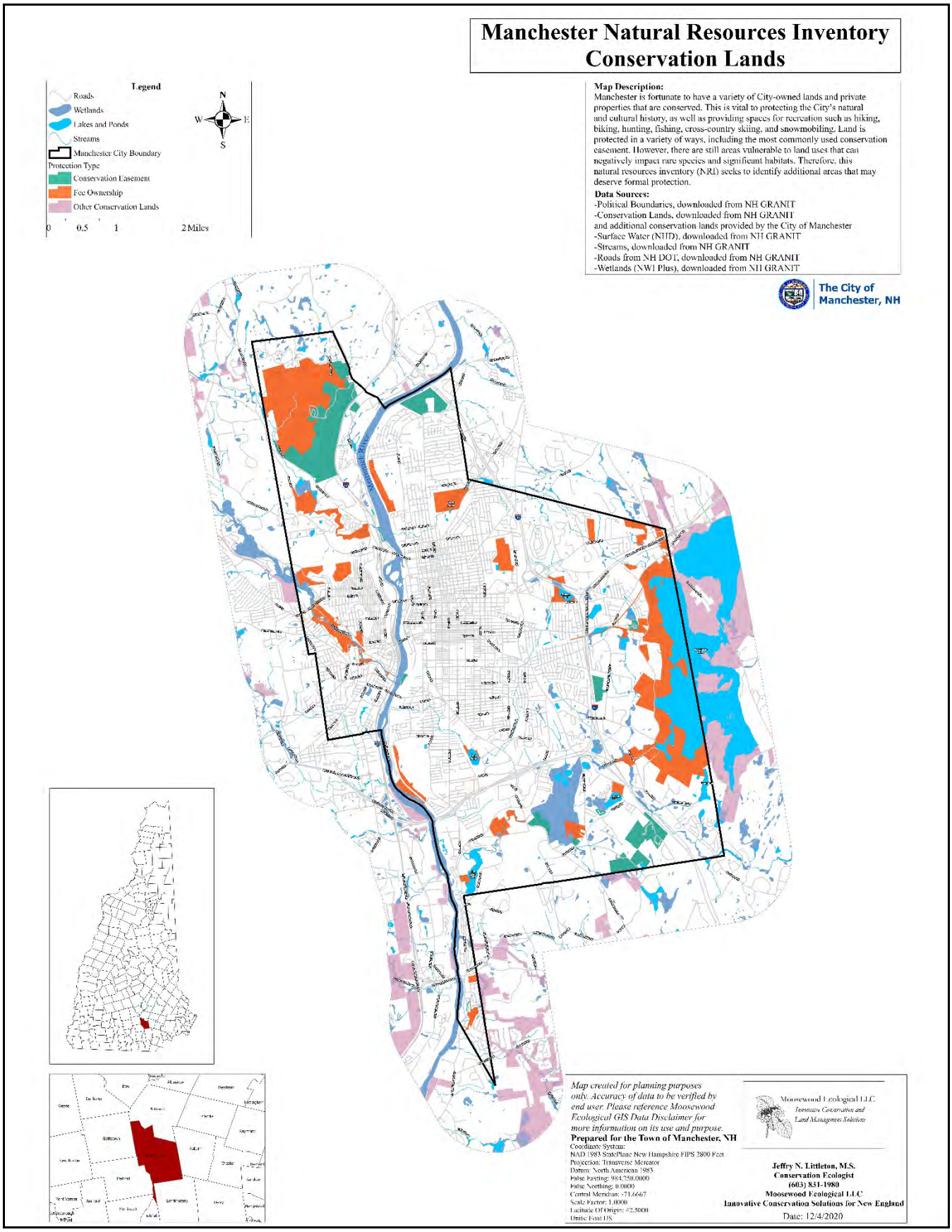

Figure 23 Conservation lands in Manchester.

CLIMATE CHANGE AND RESILIENT LANDSCAPES

Communities throughout the world are experiencing intensifying effects of global climate change, including rising annual base temperatures, more frequent and extreme storms, flooding, drought, tornados, and other weather events, rising sea levels, and changes in natural ecosystems. Several agencies and organizations have developed information and tools to help communities prepare for immediate and long-term climate change impacts. This section briefly outlines resources available from the New Hampshire Fish and Game (NHFG) Department, the U.S. Environmental Protection Agency (EPA), and The Nature Conservancy (TNC) to guide municipal conservation planning.

Climate Change in New Hampshire

Over the past century, temperatures in New Hampshire and throughout the Northeast have risen 2 -3 degrees (F), average annual precipitation has increased by 10 percent, and extremely heavy storms have increased 70 percent since 1958 (U.S. EPA 2016). The past few decades have seen earlier springs, hotter and drier summers, rising sea levels and severe storm surges that damage property and infrastructure. Continued climate-related changes will also impact agriculture, forestry, winter recreation, and other economic sectors, as well as increase human health risks through heat stress, air pollution, and insect-borne diseases like Lyme disease and West Nile virus.

Warmer annual temperatures will also promote the spread of invasive insects and plants. One example is hemlock wooly adelgid, a small invasive insect that kills eastern hemlock species. Accidentally introduced to Virginia from Japan in 1951, it has extended its range from Georgia to Maine, limited only by cold winters in northern regions. Eastern hemlock thrives in a unique ecological niche, forming dense groves on steep slopes and along stream corridors, stabilizing soils and providing shade for wildlife, including moose, black bear, migratory birds, salamanders, and diverse lichen and plant communities. As the wooly adelgid continues to extend northward, the loss of hemlock will result in cascading effects throughout forest ecosystems.

Recent research by the University of New Hampshire indicates that in the Upper Merrimack River watershed in New Hampshire, snow cover in winter may decline from the current average of 60 days per year to just 18 days per year in the next 20 to 30 years, and that

hot summer days of 90 degrees (F) or more may increase to 70 per year by the end of the century (Samal et al. 2017). This will increase the probability of flooding and accelerate inputs of nutrients, polluting the water and depleting fish species, with the most intense impacts in urban areas. Warming temperatures will also encourage further spread of invasive plants such as Asian bittersweet, Japanese knotweed, and glossy buckthorn, which outcompete native plant species that provide better food sources for migratory birds and other wildlife. This, in turn, can displace native wildlife communities from changes in plant community composition and structure. Land use policies that prevent sprawl and improved storm and wastewater infrastructure will help limit climate change related impacts and protect both terrestrial and aquatic ecosystems. More information on climate change impacts in New Hampshire can be found at the EPA's website: https://19january2017snapshot.epa.gov/climate-impacts/climate-change-impacts-state.html.

Planning for Climate-resilient Landscapes

Conservation plans traditionally have focused on identifying natural communities, existing protected lands, rare species and habitats, and resources essential for humans, such as aquifers and drinking water protection areas. The Nature Conservancy has expanded on this approach by emphasizing "ecological resilience," which is defined as the ability of plants, animals, natural communities, and ecological processes to respond to and recover from major disturbances.

Their recently released Resilient and Connected Landscapes study (Anderson et al. 2016) provides maps of climate-resilient sites, biodiversity hotspots, and corridors for species movement across eastern North America. These sites have the greatest potential for allowing species and ecological systems to survive climate-related changes over the long term and are identified through three measures of landscape-level resilience: geophysical diversity, connectedness, and biological condition. Figure 24 shows the resilient landscape for the Manchester area.

Geophysical diversity describes the variety of landforms, geology, soils, and water features that support distinctive ecological communities. New Hampshire's diverse geophysical settings, including coastal beaches and salt marshes, river floodplains, upland forests, and mountain ridgelines, each support plant and animal communities and ecological functions that have evolved within those settings. Within this geophysically diverse landscape are sites that are

relatively protected from extremes in precipitation and temperatures, and thus may provide natural strongholds for ecological communities over the long-term.

Landscape connectedness indicates the degree to which species can move across the landscape while avoiding roads, development, and other human-altered areas. Wildlife needs to access various habitats throughout their annual and life cycles, and plants need to extend their ranges over longer time periods due to changes in climate and weather. Sites that provide corridors for movement of species and ecological systems over time will allow natural systems to persist in the face of climate change.

Biological condition describes both the natural and anthropomorphic components of a site. Natural components include the species composition, presence of endangered, threatened, or rare species and communities, and ecological processes needed to maintain a natural community. Anthropomorphic considerations include impacts of human land use, air and water pollution, and introduction of invasive species.

The TNC Resilient and Connected Landscapes website describes the following concepts:

- Resilient Area: places buffered from climate change because they contain many connected micro-climates that create climate options for species.
- Flow: the movement of species populations over time in response to climate. Flow tends to concentrate in the zones and corridors described below.
- Climate Corridor: narrow zone of highly concentrated flow, often riparian corridors or ridgelines.
- Climate Flow Zone: broad areas of high flow that is less concentrated than in the corridors - typically intact forested regions.
- Confirmed Diversity: known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species.

More information on resilient and connected landscapes can be found on the TNC website:
https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/default.aspx.

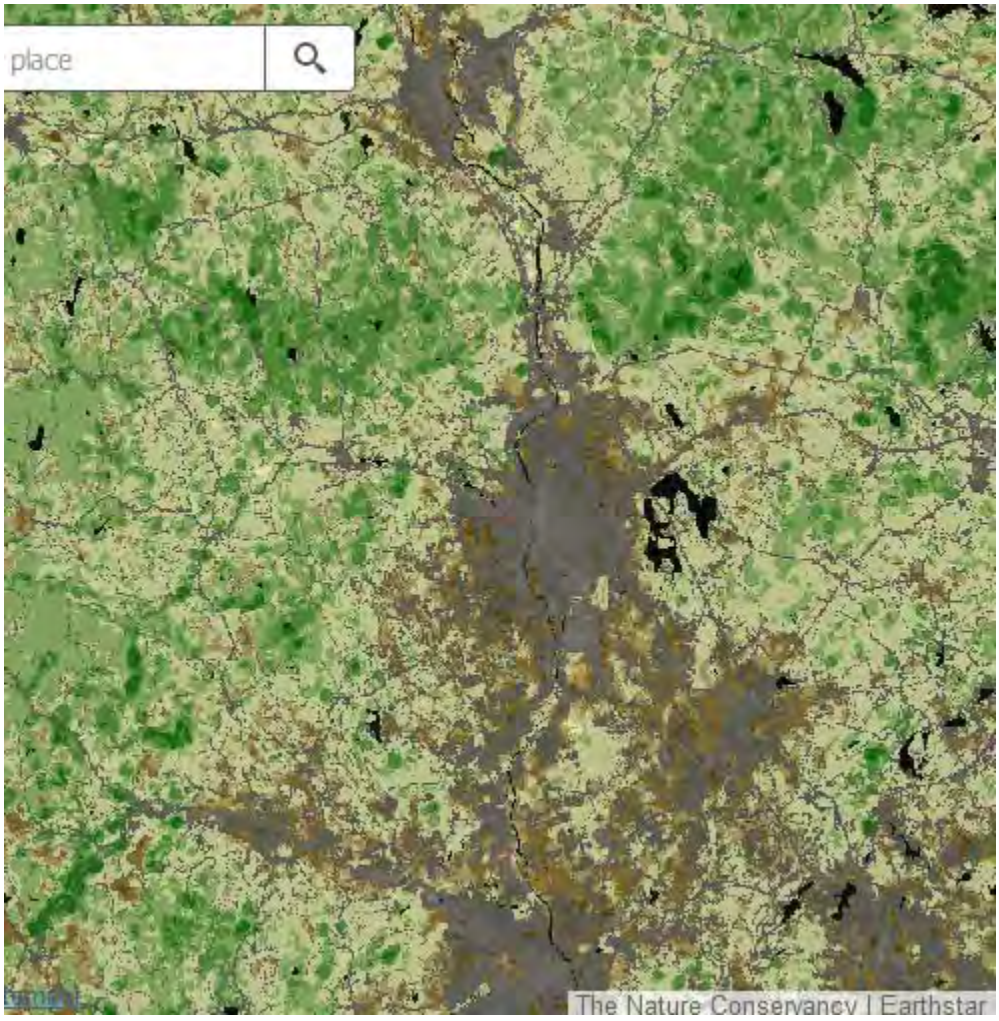

Figure 24 The Nature Conservancy resilient landscapes map for Manchester. Areas in green have higher resilience and yellow has average resilience while the brown areas are less resilient. Gray areas represent developed areas.

New Hampshire Wildlife Action Plan

In 2005, New Hampshire Fish and Game (NHFG) Department released its initial Wildlife Action Plan (WAP), which was an assessment of native species and habitats aimed at identifying those most at risk from habitat loss, pollution, invasive species, disease, and many other factors, and outlining strategies to manage and protect them. Risk assessments for species and habitats followed a protocol used by all northeastern states and yielded a list of 118 Species of Greatest Conservation Need (SGCN) in the state, as well as 27 distinct habitats that support both common species and SGCN (Fuller et al. 2005). In addition to extensive information on

species and habitats, this plan provided conservation professionals and communities with maps of ecologically significant landscapes to help guide planning and management efforts.

Over 10 years, NHFG worked with dozens of partner agencies, organizations, universities, municipalities, and volunteers to implement the plan, acquiring thousands of acres of high priority habitats for conservation, providing technical assistance to landowners and land managers, removing obsolete dams to improve fish passage, and many other actions to enhance and protect wildlife and habitats. The 2015 WAP incorporates new data and extensive public input, as well as climate change related threats. This plan identifies 169 wildlife species as SGCN, 105 of which were listed in the 2005 plan, and includes the original 27 distinct habitat types that support common and SGCN species.

Table 11 lists habitat types occurring in Manchester that are most at risk from various factors.

Table 11 2015 NH Wildlife Action Plan - Habitats at risk within the City of Manchester, NH.

WAP Habitat	**Acres**
Appalachian-oak-pine forest	2,039.6
Floodplain forest	279.0
Grassland	196.0
Hemlock-hardwood-pine forest	1,369.6
Open water	1,339.3
Peatland	84.8
Rocky ridge	2.2
Sand/gravel	81.4
Temperate swamp	138.3
Marsh and shrub wetland	569.5

For more information on the 2015 Wildlife Action Plan, go to the NHFG website: https://www.wildlife.state.nh.us/wildlife/wap.html.

SCENIC, CULTURAL, AND HISTORIC RESOURCES

The City of Manchester is rich in scenic, cultural, and historic resources. It has been at one of the centers of major commerce in New Hampshire since the 1700s. Its gentle topography combined with multiple prospects afforded by the Merrimack River and its formidable floodplains has provided ample opportunities for humans for thousands of years. Not only did the early European colonists recognize the importance and human value of Manchester's natural landscape, but indigenous peoples knew the significance of this area for their livelihood.

The landscape of Manchester has been shaped by repeated glacial events for hundreds of thousands of years. The most recent glacier that influenced the City, the Laurentide Ice Sheet, retreated about 12,000 years ago, providing the opportunity for a fresh start for wildlife, plants, people, and other organisms to recolonize the area. The glacier, through advancement and retreat, has helped to shape the landscape that drives wildlife habitats and plant communities, and ultimately land use by humans.

The Merrimack River valley contributed greatly to the City's biodiversity. Rich in assorted habitats such floodplains, wetlands, vernal pools, rocky ridges, and forests, Manchester provided an abundant food supply of wildlife and plants. Before the installation of dams, the Merrimack River boasted healthy fish populations for the bounty, some venturing from the Atlantic Ocean to spawn in the freshwaters of the Merrimack River. Moose, deer, bear, beaver, and other game provided additional forms of sustenance, as well as the many plants for harvesting, such as blueberry, huckleberry, dewberry, and so many others.

Prior to European settlement, native peoples occupied the area. The Namaoskeag Indians, part of the Penacook Tribe, inhabited the region, particularly along the Merrimack River and its rich natural resources (Searchroots 2020). This tribe inhabited the area around Amoskeag Falls, which served as a favored fishing ground for the Penacooks for thousands of years. Roughly translated, the work Amoskeag means "place of many fish." It is believed that Chief Passaconnaway would take up residence here during the fishing season, and it also provided a perfect meeting location for all the other Penacook tribes that revered him as their chief, or *sagamore*. Undoubtedly, due to the various natural resources associated with the Merrimack River and Massabesic Lake, there are numerous archaeological sites in Manchester. One such site is privately owned, being associated within the vicinity of the Amoskeag Bridge.

Upon European settlement in the early 1700s, the land quickly changed. It was incorporated in 1752 as the town of Derryfield, and eventually renamed Manchester in 1810 (Searchroots 2020) at the beginning of an era known as sheep fever. The floodplains provided for excellent farmlands for annual crops, while surrounding areas provided space with pastures for various livestock. Woodlots also adorned homesteads with a source of fuel for cooking and heating. Stonewalls can still be seen in undeveloped areas of the City. These stone walls provide testament to the various farming practices by Manchester's early settlers.

The Merrimack River was another major asset. This water resource provided the means for transportation, food, and energy for what was to become a bustling mill industry, providing jobs for a large workforce. Amoskeag Mill Companies was instrumental with the development of commercial cotton and woolen mills along the Merrimack River (Searchroots 2020). It is believed that this company greatly influenced the prominence of Manchester today. These mills have changed their names and ownership numerous times but have provided a consistent labor force to fuel the economy of the City and surrounding towns. Therefore, the value of the natural resources provided by the Merrimack River has been instrumental in Manchester's cultural history leading to the present times.

The Manchester Cedar Swamp Preserve provides a unique perspective for Manchester's natural landscape and its history. Parts of the area are rugged with glacial erratics and some bedrock outcropping and scattered wetlands that limited its use as farmland. However, certain areas were cleared for pasture just as the adjacent Hackett Hill area. Part of the Hackett Hill conservation area was originally slated to become UNH's Manchester Campus, but the state decided to relocate the campus to the mills along the Merrimack River. While the physical evidence has been mostly erased, it is surmised that many of the conservation lands in Manchester have experienced a long history of land use ranging from agriculture to logging and railways to sports fields.

Other historical uses of the natural resources on conservation lands include the following accounts (City of Manchester 2021):

- Black Brook and Maxwell Pond at Blodgett Park was originally used for ice harvesting by the Amoskeag Ice Company soon after the dam was created in 1900. It also served as a popular spot in the summer for swimming, fishing, and picnicking and in the winter months for ice skating, hockey, and bonfires until the

late 1950s. Excess sedimentation into the stream from upstream developments in the late 1950s and 1960s drastically reduced the water depth of Maxwell Pond. By 2005, the depth of the pond was less than 4 feet, and water quality has diminished to the point that the waterbody was put on the list of impaired waters by the New Hampshire Dept. of Environmental Services. The dam was removed in 2009 due to safety concerns around flooding and the deteriorating condition of the dam. This restoration of Black Brook now provides aquatic connectivity for a variety of aquatic and semi-aquatic species to freely move up and down stream without the impediments of the dam. Today, it is used for walking along its nature trails and fishing.

- Historically known as Skenker's Pond and Mosquito Pond, The City of Manchester opened Crystal Lake as a public swimming spot and picnic area on the northern end in 1919. It is accessible today from Crystal Lake Park. Melody Pines Day Camp was established in 1952. This private day camp has been handed over to and managed by three generations as a family business.
- Livingston Park provides public access to Dorrs Pond for paddling canoes and kayaks. In the early to mid-1700s, Ray Brook (and what is now known as Dorrs Pond) was used to power a sawmill. After his father's death in 1758, John Stark (Revolutionary War hero) took over operations at the mill. General John Stark abandoned the mill to fight in the War, and it was never used again. Ray Brook was dammed in 1862, creating Dorrs Pond, and was used for ice harvesting. It was believed that elephants from travelling circuses were taken to Dorrs Pond to cool down. Amoskeag Manufacturing Company purchased the property in the early 1900s and removed the dam due to its "biological richness and nuisance sports fishing for the stocked German carp." Then, in 1923 the Company deeded the property to the City to be used as a summer swimming area. While it quickly became a popular swimming hole it soon lost its popularity in the 1930s.
- Precourt Park provides boat access to Nutt Pond. This pond has had several names over the years and had many uses as well. In the mid-1700s a wooden garrison was built to provide colonists a safe haven from "Native American attacks." The Manchester Coal and Ice Company harvested ice from Nutt Pond until the 1920s.

Ice harvesting most likely began in the 1860s and was owned by three other companies before the Manchester Coal and Ice Company owned the rights to harvest ice. In 1938, Nutt Pond became a popular recreation area and swimming hole. Due to the increased popularity of Nutt Pond for swimming, the NH Fish and Game treated the pond with chlorine, which eliminated the need to manage it for its fisheries. The Manchester Coal and Ice Company sold the northern lot to the City in 1951. In the 1950s and 1960s, Nutt Pond became even more popular for swimming but was closed as such in 1968 due to high levels of bacteria despite continued efforts to treat the pond with chlorine. It was later determined that the pollution that increased the rates of bacteria was from a sewer fallout upstream of the pond. The continued pollution problem resulted from commercial and multi-family housing during the 1960s and 1970s. Today, Nutt Pond still has issues with pollution as documented through annual water quality monitoring efforts by the Urban Ponds Program.

- Pine Island Pond is accessible from Pine Island Park along its western shore. An amusement park was developed at Pine Island Park by Manchester Traction, Light & Power Company in 1902. Pine Island Pond was also used for swimming and paddling. It closed in 1962. At one point the park served as a 4-H educational center. It still remains a popular area for swimming and fishing.
- Access to Stevens Pond is provided by City property via a boat ramp on its southern shore. Today, it is still used for paddling, bird watching, fishing, and skating. In 1952, NH Fish and Game attempted to kill off all fish species in the pond in an attempt to create small-mouth bass fishery. While the kill was not totally complete, they did stock the bass over a 2-year period, while also introducing two species of crayfish. Fish surveys conducted in 1958 revealed that the dominant fish in Stevens Pond was brown bullheads and common suckers despite the attempt at creating a small-mouth bass pond. The water quality soon deteriorated after the construction of Interstate 93 in 1964. Water quality sampling from 1981-1997 indicated dramatic increases in conductivity, sodium, and chloride due to toxic runoff from the Interstate. Water sampling since has still indicated elevated levels of a variety of pollutants.

Conservation lands, cemeteries, and City parks provide part of our cultural identity within Manchester (Figure 26). Some conservation lands, such as the Manchester Cedar Swamp Preserve, are open to the public. However, not all conservations are accessible by the public as they may be privately-owned. All City-wide parks are open for public use and enjoyment. There are a total of 46 City parks distributed throughout the Queen City (Table 12). These total over 1,000 acres of publicly-owned lands. Popular sites include Rock Rimmon Park, Piscataquog River Park, and Great Cohas Swamp.

Figure 25 A spectacular view of the Queen City from atop Rock Rimmon.

Table 12 List of City Parks by acreage.

Park Name	Park Type	Acres
Arms Park (Riverfront Park)	River Park System	4.7
Bass Island	River Park System	1.3
Bronstein Park	Downtown Park	2.8
Brown-Mitchell Park	Neighborhood Park	2.1
Calef Road Tennis Courts	Neighborhood Park	2.1
Crystal Lake	City-Wide Park	15.4
Derryfield Country Club	City-Wide Park	116.4
Derryfield Park	City-Wide Park	93.5
Enright Park	Neighborhood Park	0.9
Gateway Park	River Park System	0.5
Gill Stadium	City-Wide Park	8.1
Goffs Falls Park	Neighborhood Park	2.9
Great Cohas Swamp	River Park System	84.2
Harriman Park	Neighborhood Park	0.4
Howe Park	Neighborhood Park	1.2
John F. Kennedy Collisum	City-Wide Park	2.3
Kalivas Park	Downtown Park	1.5
Koscuisko Park	Downtown Park	0.0
Lafayette-Simpson Park	Neighborhood Park	3.1
Livingston Park	City-Wide Park	132.9
Martineau Park	Neighborhood Park	0.2
Massabesic Lake Park	City-Wide Park	13.8
McIntyre Ski Area	City-Wide Park	54.3
Medford Street Park	Neighborhood Park	4.5
Oak Park	Neighborhood Park	2.6
Pine Island Park	City-Wide Park	8.1
Piscataquog River Park	River Park System	112.5
Precourt Park	City-Wide Park	32.3
Prout Park	Neighborhood Park	5.7
Pulaski Park	Downtown Park	2.3
Raco-Theodore Park	City-Wide Park	6.6
Rock Rimmon Park	City-Wide Park	106.6
Saint Anthony Park	Neighborhood Park	7.7
Samuel Blodget Park	City-Wide Park	44.6
Sheehan-Basquil Park	Neighborhood Park	8.1
Sheridan-Emmett Park	Neighborhood Park	5.2
Stanton Plaza	Downtown Park	0.9
Stark Park	City-Wide Park	29.9
Stevens Park	Neighborhood Park	5.2
Stevens Pond	City-Wide Park	49.4
Sweeney Park	Neighborhood Park	1.6
Veterans Memorial Park	Downtown Park	3.8
Victory Park	Downtown Park	2.0
Wagner Park	Neighborhood Park	1.5
Wolfe Park	Neighborhood Park	10.5
Youngsville Park	City-Wide Park	16.6

Cemeteries also serve as a cultural resource. There are 15 cemeteries in Manchester, totaling 220 acres (Figure 26). These areas provide a sense of history, as well as places for leisurely walks and often times great birding spots. Access to and enjoyment of water resources for recreation is a major part of our culture. There are several locations where access to public waters is available (Figure 26). These include a beach at Crystal Lake Park; five boat launches to access the Merrimack River, Piscataquog River, and Humphrey Brook; two cartop launches for canoes and kayaks along the Merrimack River at the Amoskeag Bridge and Dorr's Pond at Livingston Park; and two points of foot access, including one to the Merrimack River at Arms Park (Riverfront Park) and one at Pine Island Pond at Pine Island Park.

An additional cultural resource includes the Urban Ponds Program in Manchester, which was established in 2000 (City of Manchester 2021). The initial tasks of the Program included evaluating and monitoring seven ponds to assess their potential for restoration. These included Crystal Lake, Dorrs Pond, Maxwell Pond/Black Brook, McQuestion Brook, Nutt Pond, Pine Island Pond, and Stevens Pond. The original goal of the project was to "return the ponds to their historic uses (such as boating, fishing, and swimming)." To meet this goal, the following objectives were identified:

1. Promote public awareness, education, and stewardship.
2. Reduce pollutant loading and nutrient inputs to improve water quality.
3. Maintain or enhance biological diversity.
4. Provide improved recreational uses at each pond.

The City has worked on a variety of restoration projects since 2000. In addition, it continues to work on other activities, including:

- Annual maintenance of 10 informational kiosks
- Annual e-newsletter
- Annual spring pond and park cleanups
- Annual water quality sampling and data analysis
- Publication updates. Social media and website updates.

The program received an Environmental Merit Award from the Environmental Protection Agency in 2011. This award recognizes the outstanding contributions for the protection of New England's environment. In addition, the Mayor and Board of Aldermen formally recognized several long-time volunteers for their contributions at pond and park cleanups. For more information on the program, including the results of the pond cleanups and water quality monitoring see the following website, please visit the Environmental Protection Department's page on pond restoration on the City of Manchester's website.

Being rich in wetlands, rivers, and streams, Manchester has numerous scenic views that offer observers the opportunity to appreciate Manchester's landscape (Figure 26). The Piscataquog River Park provides some stunning views of the river from both the trail system, as well as from the bridge overlooking the vast view of the Piscataquog River. Similarly, Rock Rimmon affords an opportunity to overlook the City from atop a rocky prominence that sits about 100 feet above the City. In addition, the numerous access points for public waters also provide scenic opportunities to appreciate Manchester's landscape.

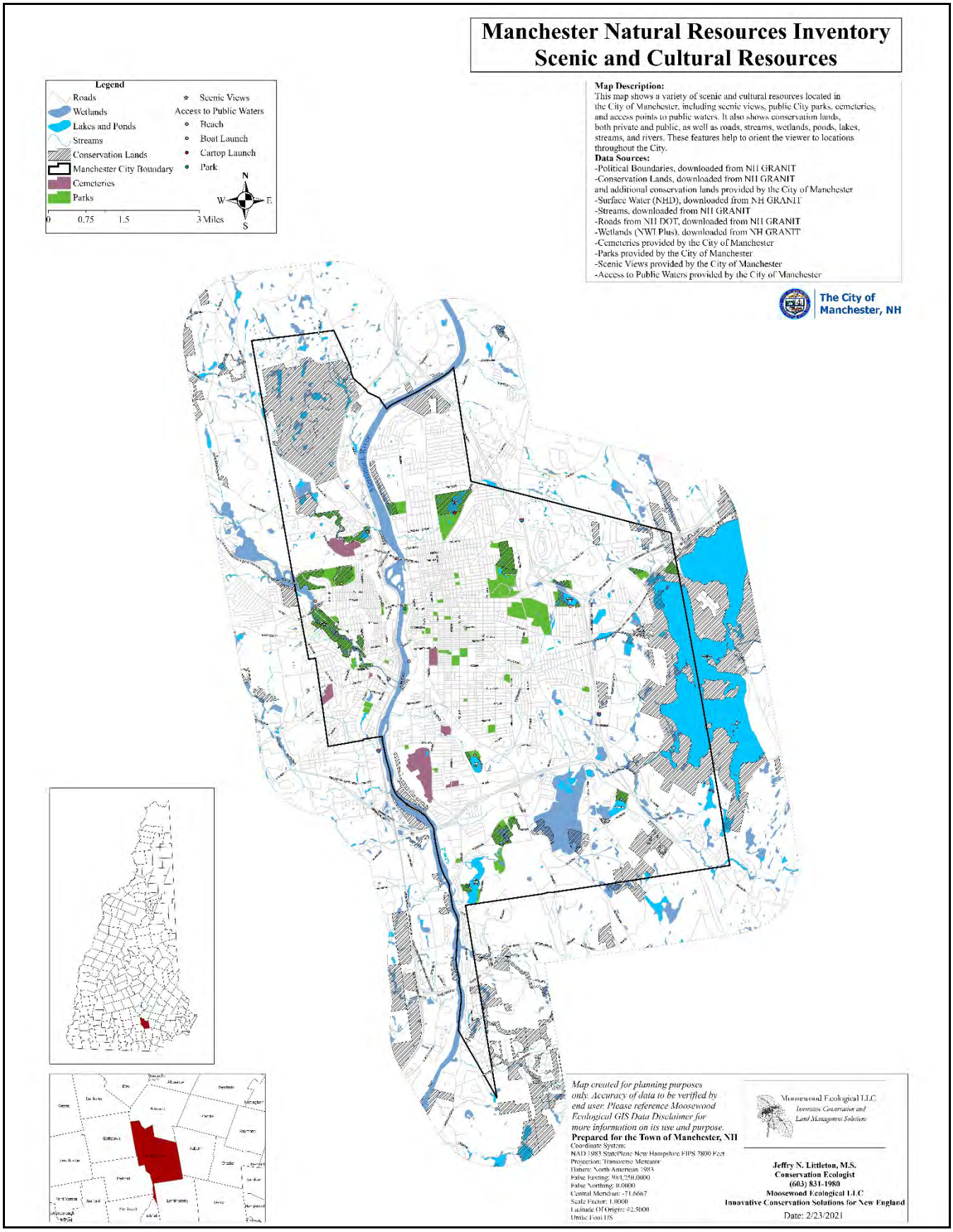

Figure 26 Scenic and cultural resources in Manchester.

CONSERVATION FOCUS AREAS and POTENTIAL MITIGATION SITES

This section provides guidance for future conservation planning in the City. The areas of focus should be the use of land acquisition to protect natural resources and the mitigation of human impacts on the environment with natural resources management, such as managing stormwater and invasive plants. Due to the high degree of development combined with the distribution of conserved lands, Manchester has limited open space available. As such, this creates a challenge for effectively mapping CFAs. Therefore, we have provided a list of sites and/or specific natural resources to serve as CFAs and potential sites for mitigation.

1. The protection and restoration of any existing floodplains and their streams, as well as their existing natural buffers. This effort could protect significant habitats and benefit rare species such as bald eagle, Jeffersons salamanders, and Wright's spikesedge (State-endangered), as well as potentially rare natural communities.
2. The protection of all wetlands, especially high value wetlands, and their existing natural buffers. This effort could help protect habitat for rare reptiles and plants.
3. The protection of stream and river shorelines and their existing natural buffers, particularly focusing on the Merrimack River, Piscataquog River, and Cohas Brook. This effort could help protect habitats for rare natural communities, plants, and wildlife.
4. The City should expand efforts to build upon land protection for natural habitats adjacent to existing conservation lands. This would maximize biodiversity and overall conservation values.
5. The City should continue to pursue restoration efforts for the Urban Ponds Program to help reduce toxic pollutants and manage invasive plants. Based on historical averages of water quality data, the following appear to be priorities for mitigation planning based on the latest water quality reporting through the City's Stormwater Management Program (McNeill 2018).
    a. Dorrs Pond, Nutt Pond, and Pine Island Pond have chlorophyll-a levels that are "more than desirable."
    b. Dorrs Pond inlet, Nutt Pond, and Stevens Pond may exceed the threshold for chloride on more than one occasion throughout the monitoring season.

c. Conductivity levels for Crystal Lake and Pine Island Pond are listed as "moderate impact," while levels in Dorrs Pond and Nutt Pond have "high impact" and Stevens Pond is considered as "exceeding chronic chloride standards."
d. Dorrs Pond, Nutt Pond, Pine Island Pond, and Stevens Pond has "high to excessive" levels of phosphorus.
e. Dorrs Pond (Juniper Street inlet), Nutt Pond, and Stevens Pond "may exceed the threshold for turbidity on more than one occasion throughout the monitoring season."

6. The following have been identified by the NH Dept. of Environmental Services and US Environmental Protection Agency as impaired waters under the Clean Water Act section 303(d): Crystal Lake, Dorrs, Pond, Pine Island Pond, Nutt Pond, Stevens Pond, Cohas Brook, Black Brook, Rays Brook, Baker Brook, Humphrey Brook, Merrimack River, and Piscataquog River.
7. The City would greatly benefit from the replacement of undersized and perched culverts to provide aquatic connectivity and help alleviate issues with flooding and excess sedimentation. A good example of an undersized culvert can be found under South Mammoth Road in association with the wetland and stream adjacent to parcel 797-8. This stream runs west and joins Cohas Brook in the Great Cohas Swamp.
8. Great Cohas Swamp along the Cohas Brook off Mammoth Road is ranked as a high value wetland, as well as the highest ranked habitat in the NH Wildlife Action Plan. Great Cohas Swamp is a highly diverse wetland system and floodplain that is a prime spot for ecological restoration. Land acquisition of adjacent natural habitats, as well as stormwater and invasive plant management provide excellent opportunities for mitigation.
9. A good habitat restoration projects includes the old, steep river bank west of Pine Grove Cemetery. This area (also known as Pine Grove Cemetery Backlands) and the Smith's Ferry Heritage Park are prime spots for invasive plant management. The cemetery, steep bank, and floodplain provide a good birding area along the Merrimack River. Installation of pollinator plots within the cemetery would not only enhance wildlife habitat but provide a more aesthetically pleasing environment.

10. The City should review stormwater management sites and prioritize areas that are in need of upgrading to better mitigate the effects of runoff from roadways, parking lots, and other impervious surfaces. Rain gardens can provide a passive source of stormwater management when sited and designed correctly. Typically, these rain gardens include native plants that are beneficial to a variety of pollinators and birds.
11. Manchester should continue to preserve and re-establish tree canopy cover throughout the City, as mentioned in the City's draft Master Plan (Town Planning & Urban Design Collaborative, LLC 2020). This helps to provide clean air, cool streets and buildings, prevent soil erosion, and provide wildlife habitat particularly for birds and pollinators.
12. One particular area that would benefit from habitat protection includes lands to the north, south, and west of the conserved properties associated with Massabesic Lake. Protection of the natural habitats surrounding this area would help protect hemlock-hardwood-pine forests and Appalachian oak-pine forests (which may contain natural communities), as well as potential vernal pools. This may also help to protect upland habitat for rare reptiles.
13. Rock Rimmon would greatly benefit from invasive species management, especially within the rare natural communities.
14. Five major areas in Manchester are noted as having high ecological and conservation values, including lands around Massabesic Lake and Manchester Water Works properties; Great Cohas Swamp and Brook; Piscataquog River; Merrimack River; and Manchester Cedar Swamp/Hackett Hill area. All City-owned properties adjacent to these areas may warrant protection, including the following.
    a. Cohas Brook and Great Swamp area parcels: 856-3B, 853-34, 885-1, 858-2, 858-3, 858-4, 787-2A, 787-2, 851-1B, and 719-1
    b. Tributary to Cohas Brook from Crystal Lake parcels: 506-1, 506-42, 506-40, 506-41, 506-39, 506-38, and 506-43
    c. Massabesic Lake/Manchester Water Works area parcels: 761-2A, 765-21, 761-11, and 765-22

RECOMMENDATIONS

The information provided herein, including the various maps, can be used when considering the adoption of various land use planning techniques or when working with willing landowners on resource protection efforts. The data used to develop this information represents the most current, readily available data to better understand Manchester's natural resources. As such, there are some basic guidelines that the City can use to promote innovative and informed land use planning.

- Protect known rare species populations;
- Protect representative examples of critical habitats for known rare species;
- Protect rare and representative examples of natural communities;
- Protect intact wetland and stream riparian buffers and promote the restoration of degraded areas;
- Support voluntary and regulatory approaches at natural resources protection;
- Build upon existing contiguous protected lands;
- Connect protected lands and other critical habitats with upland, aquatic, and/or riparian corridors, thereby effectively creating green corridors;
- Better understand wildlife movement patterns to identify and design the most effective conservation corridors; and
- Promote community education and outreach regarding Manchester's biodiversity and the importance of long-term protection strategies.

The following general recommendations were based on the findings of the project. These suggested steps should be taken into consideration as Manchester proceeds with community land use planning and education:

1. Incorporate the NRI into the recently developed Manchester Master Plan. This provides a vision for the City from which adaptive land use, conservation, and mitigation planning can be adopted. Also, continue working on other recommendations in the Environment sections of the Master Plan.

2. Develop a comprehensive Conservation Plan that incorporates the data and findings of this NRI. This is the natural next step after the development of an NRI, which provides a detailed road map for conservation and mitigation planning.

3. Build public support for the NRI through informational sessions, published materials, and other means of community education and outreach. This will help to inform the community about its natural resources and future planning.

4. Use the information within the Conservation Focus Areas (CFAs) chapter as a tool for future land protection efforts with landowners willing to engage in land conservation, resource mitigation efforts, and land use regulations and zoning ordinances. Some general guidelines for CFAs have been provided along with specific sites to prioritize. These do not necessarily represent the only focus areas, and situations may change in the future that warrants protection of other areas outside of those mentioned for CFAs. These should be handled on a case-by-case basis.

5. Develop stewardship plans for City-owned lands, incorporating data from this NRI with other existing information on these properties such as forest management plans. Typical elements addressed in stewardship plans include wildlife and habitats, rare species, soils, natural communities, invasive plants and forest pathogens, recreation, forestry, and cultural features. However, since each property is different there may be other aspects to consider. Stewardship recommendations should clearly address management goals and specifically outline short and long-term resource protection measures, including appropriate buffers around sensitive habitats and natural communities, rare plant populations, and cultural features, as well as management activities to foster the proper utilization and enhancement of natural resources.

6. Support efforts to conduct common nighthawk surveys within the City. This is a species of greatest conservation need in NH, and the last time it was observed, according to NH Natural Heritage Bureau, was in 1985. This species is known to build nests on top of suitable buildings. If it is learned that nighthawks are present, then the City could team up with NH Audubon and NH Fish and Game to develop nesting sites in appropriate locations.

7. Due to the tremendous number of culverts within Manchester, it is highly recommended to conduct an assessment throughout the City to prioritize stream restoration sites based on undersized and/or perched culverts. This effort can help alleviate issues associated with flooding and soil erosion while providing aquatic connectivity for wildlife, some of which are rare and would greatly benefit from these restoration efforts. These would make for great mitigation projects for the City.

8. There are at least 2 rare species of grassland birds (one is State-threatened and the other a species of special concern) known to use the City-owned property (Tax Map 768-38) located at 535 Dunbarton Road, which is managed by the Manchester Highway Department. It is highly recommended that this property should be managed for grassland birds. This would include delayed mowing (after August 1st) to protect nestlings until they fledge the nest. Grassland birds and their habitat have been dramatically decreasing over the past several decades.

9. Continue to work with adjacent communities on similar conservation initiatives of common interest. It would be helpful to meet annually with the Conservation Commissions within each of the adjacent communities to build strong relationships and create open lines of communication, as well as to inform these communities about Manchester's conservation planning efforts.

10. Continue with community outreach and landowner education regarding Manchester's natural resources and conservation planning. This can be accomplished in many ways, including workshops, hikes, and printed materials, such as brochures and maps, to help landowners with resource protection and management. A subcommittee of the Conservation Commission could be developed to focus on outreach and education efforts.

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APPENDIX A

GIS DATA AND USE DISCLAIMER

Moosewood Ecological LLC GIS Data Disclaimer

A variety of existing and newly created data layers were used to prepare the Natural Resources Inventory (NRI) maps. These existing data have been developed by numerous government agencies and other sources. They have been produced specifically for the City, the state of New Hampshire, or the entire United States using *remote data*. These sources of remote data were developed from the interpretation of satellite imagery and aerial photography. The data were produced at various scales and therefore, represent different degrees of errors, omissions, and inaccuracies.

The NRI maps are for planning and educational purposes only. They are suitable for general land use planning. However, they are not suitable for detailed site planning and design, including wetlands delineations and other jurisdictional determinations. As such, boundaries of all habitats, including wetlands, and parcels are approximate locations and should be field verified. The accuracy of the data is the end user's responsibility, and Moosewood Ecological LLC cannot be responsible for the accuracy and completeness of the data. Moosewood Ecological LLC makes no warranty, expressed or implied, as to the accuracy or completeness of the data. Furthermore, Moosewood Ecological LLC shall assume no responsibility for any errors, omissions, or inaccuracies in the information provided.

APPENDIX B

HABITAT BLOCK SIZE REQUIREMENTS FOR WILDLIFE

1-19 Acres	20-99 Acres	100-499 Acres	500-2,500 Acres	>2,500 Acres
raccoon	raccoon	raccoon	raccoon	raccoon
	hare	hare	hare	hare
				coyote
small rodent	small rodent	small rodent	small rodent	small rodent
	porcupine	porcupine	porcupine	porcupine
				bobcat
cottontail	cottontail	cottontail	cottontail	cottontail
	beaver	beaver	beaver	beaver
				black bear
squirrel	squirrel	squirrel	squirrel	squirrel
	weasel	weasel	weasel	weasel
		mink	mink	mink
				fisher
	woodchuck	woodchuck	woodchuck	woodchuck
		deer	deer	deer
muskrat	muskrat	muskrat	muskrat	muskrat
			moose	moose
red fox	red fox	red fox	red fox	red fox
songbirds	songbirds	songbirds	songbirds	songbirds
		sharp-shinned hawk	sharp-shinned hawk	sharp-shinned hawk
			bald eagle	bald eagle
skunk	skunk	skunk	skunk	skunk
		Cooper's hawk	Cooper's hawk	Cooper's hawk
		harrier	harrier	harrier
		broad-winged hawk	broad-winged hawk	broad-winged hawk
			goshawk	goshawk
		kestrel	kestrel	kestrel
			red-tailed hawk	red-tailed hawk
		great-horned owl	great-horned owl	great-horned owl
			raven	raven
		barred owl	barred owl	barred owl
		osprey	osprey	osprey
		turkey vulture	turkey vulture	turkey vulture
		turkey	turkey	turkey
most reptiles	most reptiles	reptiles	reptiles	reptiles
	garter snake	garter snake	garter snake	garter snake
	ring-necked snake	ring-necked snake	ring-necked snake	ring-necked snake
most amphibians	most amphibians	most amphibians	amphibians	amphibians
		wood frog	wood frog	wood frog